

## CHAPTER 1

### GENERAL DESCRIPTION AND OPERATION

#### 1.0 General Description

The MEK6802D3 board (see Figure 1.0.1) is designed to be a single board microcomputer, for use in both the educational environment and for computer based system applications.

This system employs the MC6802 microcomputer chip. It also contains 256 bytes of user RAM (MCM6810) and 128 bytes of operating system (OS) stack. The operating system software (called D3BUG) is contained in the 2K bytes of Read Only Memory (ROM) storage of the MC6846. The keyboard and eight seven-segment displays are used in conjunction with D3BUG to enter and debug user programs. The I/O port of the MC6846 is accessible through a 16 pin socket for external control of user defined applications such as timers, relay control, etc.

Provisions are made for system expansion through the system bus. The D3BUG operating system is expanded by 2K bytes (MCM68316) to accommodate additional features and commands necessary for the expanded system. Also the system bus has additional signals to support eight levels of memory paging. Hence, the expanded operating monitor with 100% memory decoding and paging can make the MEK6802D3 a very flexible and powerful computer system.

#### 1.1 Address Space (stand-alone computer)

The address space organization of the MEK6802D3 computer board is given in the address map (see Figure 1.1.1). Chapter 3 gives a functional

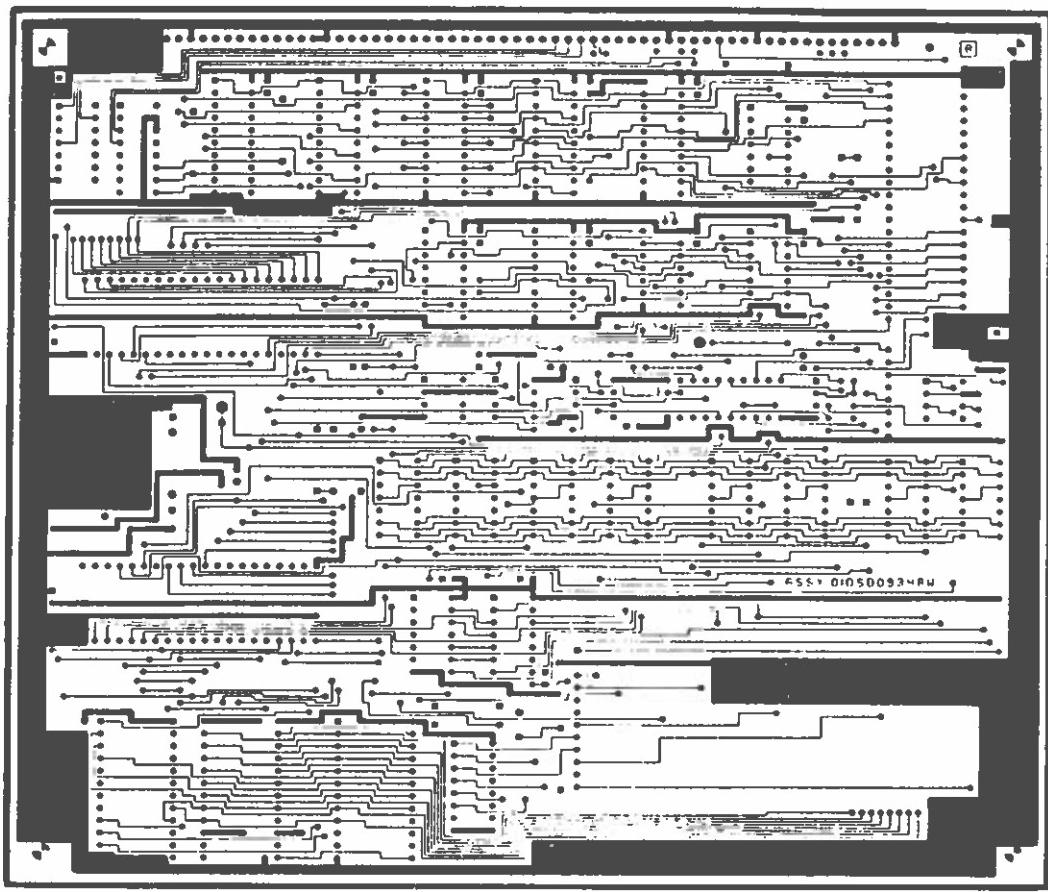


FIGURE 1.0.1. MEK6802D3 BOARD

\$FFFF	MC6846 ROM	D3BUG
\$F800		
\$81FF		
		USER STACK OPTIONAL USER STACK - RELOCATABLE FROM \$0080
MCM6810 RAM		
\$8180		
\$817F		
MCM6810 RAM		D3BUG OPERATING SYSTEM STACK
\$8100		
\$808B	MC6821	KEYPAD/DISPLAY PIA
\$8088		
\$8087		
\$8080	MC6846	I/O - TIMER
\$00FF		
MCM6810 RAM		USER STACK - RELOCATABLE TO \$8180
\$0080		
\$007F		
MC6802 RAM		USER STACK - CAN BE DISABLED WHEN USING OFF-BOARD MEMORY
\$0000		

FIGURE 1.1.1. ADDRESS MAP

1.1 Address Space (stand-alone computer)(cont'd)  
description for the address space configuration for an expanded system.

1.2 Firmware Features

The 2K firmware monitor for the MEK6802D3 microcomputer system, D3BUG, resides in the MC6846. The function of the monitor is to provide a means for communication with and control of the system microprocessor by using the keyboard and display. D3BUG has the following capabilities and features:

1. Examine and change memory locations with ability to increment to next location or decrement to previous location.
2. Automatically verify memory change by displaying both the digits entered and the actual contents of memory.
3. Display and change MPU registers.
4. Calculate offsets for branch instructions.
5. Single step trace of programs in both RAM and ROM.
6. Set, clear, and examine up to 8 breakpoints.
- \* 7. Punch designated memory to audio cassette using the expansion I/O board, MEK68IO, at either 300 or 1200 baud rate.
- \* 8. Load cassette tape into memory.
- \* 9. Verify tape after punching or loading.
10. Go to and execute user program.
11. Abort user program.
12. Execute any keyboard control functions during execution of user program.
13. User definition of each of the hexadecimal keys to correspond to a user program.

## 1.2 Firmware Features (cont'd)

14. Optional user definition of interrupt vectors.
  15. Access to monitor subroutines for user programs.
- \* Features 7, 8, and 9 can only be used in an expanded system with a MEK6810 board.

## 1.3 Preparation For Use

The MEK6802D3 requires a single +5 V power supply (5% tolerance) with a maximum current capacity of 0.9 amps. The kit comes with a 5 pin contact wafer assembly which can be used to attach the power through the PC board connector. Two wires (at least 22 gauge) must be soldered to the contact wafer assembly as shown in Figure 1.3.1.

The 5 pin contact wafer assembly pins are accessible at both ends and the two wires are soldered to the short pin side. The longer pin side is mated to the PC board connector (pins 1-5) as noted in Figure 1.3.1. To insure that the soldered wires do not short to other pins, it is recommended that sleeving is used on the two soldered pins.

Before the power supply is connected to the PC board, be sure that the surface that is to support the D3 card is a non-conductive material such as wood. Next, make sure that the power supply is off before connecting the connector assembly to the PC board.

## 1.4 Start Up Procedure

When the power supply is switched on, a prompt sign (=) should appear in the left most display (marked 1 in Figure 1.3.1) and the remaining displays should be blank. If the display does not come up in this mode, press

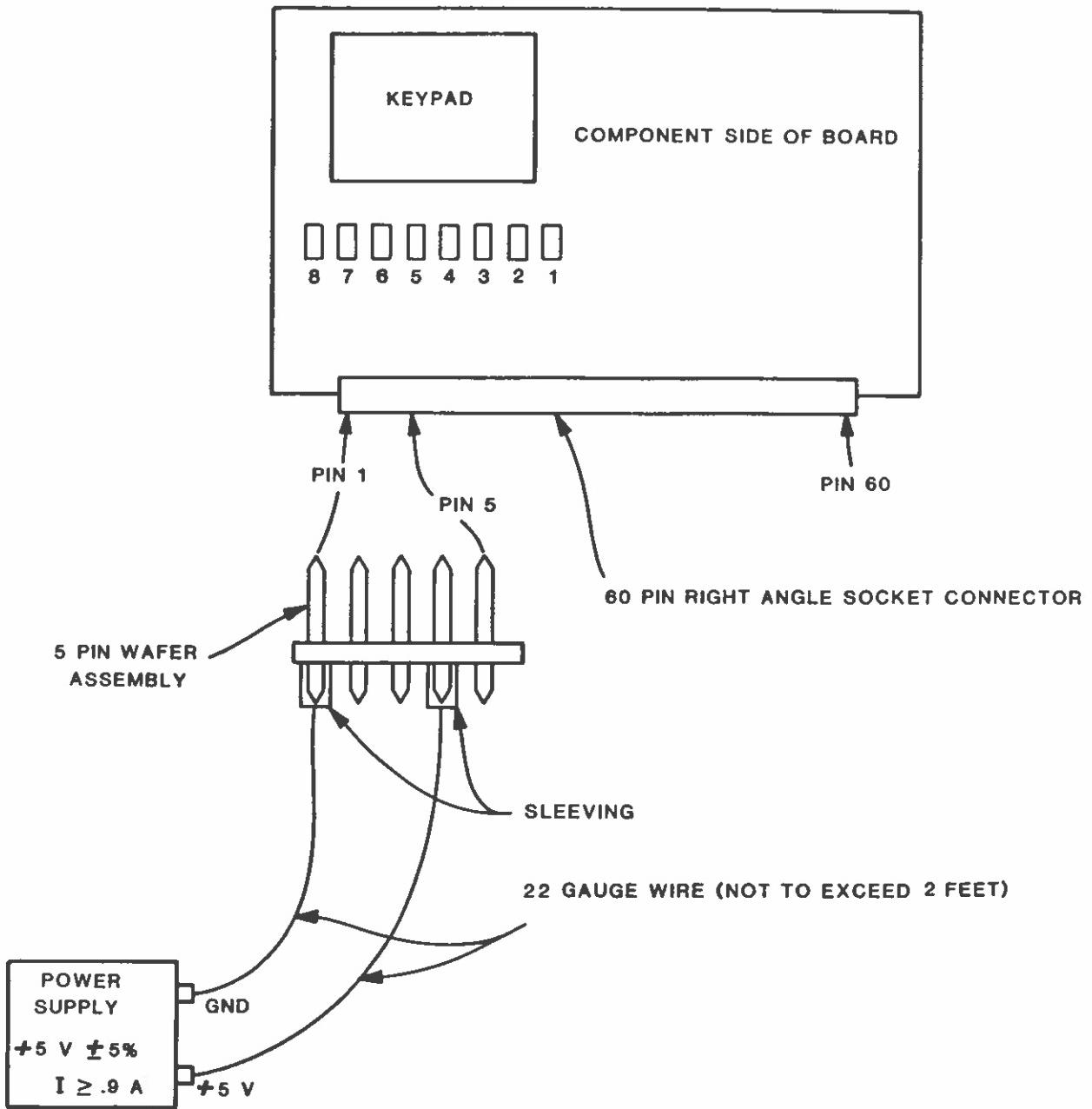


FIGURE 1.3.1. POWER CONNECTION

#### 1.4 Start Up Procedure (cont'd)

the RS button on the keypad. When RS is depressed momentarily, the display should go to the state described when power was first turned on. If the display registers something different, then turn off the power supply and check for proper connection and continuity of the power connector. Also check to make certain that the power supply is within the specified +5 V  $\pm$  5% range.

When the power is on and all displays blank except the prompt sign (=), the monitor (D3BUG) firmware is now in operation and any of the functions described in the next section may be invoked by means of the data and command keys of the keypad.

#### 1.5 Operating Procedure

The keypad/display, in conjunction with D3BUG provides examine operations for the computer and entering and trouble-shooting of programs. The keypad has sixteen keys labeled 0 - F for entry of hexadecimal data and nine keys for commanding the following functions.

- RS - System Reset
- M - Memory Display
- G0 - Go
- EX - Escape
- FS - Special Function
- T/B - Trace/Breakpoint
- RD - Register Display
- P/L - Punch/Load
- FC - Clear Special Function

## 1.5 Operating Procedure (cont'd)

Operating procedures for each of these functions are described in the following paragraphs with the exception of the P/L operation which will be covered in detail in Chapter 3.

RS : Reset key re-initializes the monitor and places a (=) prompt on the display.

M : The memory display key is used to display and alter data stored in memory. The function is invoked by entering the hex address and depressing the M key. The first four displays provide the address. The middle two displays will contain any hex numbers which may be entered by the user. The far right two displays will show what is stored at that address. If the address is not in RAM, the far right display may not be the same as the middle display. To step towards high memory, type GO and the next higher memory location will be displayed. To examine a previous memory location, type M and the previous memory location will be displayed.

The memory display function contains a subfunction which calculates offsets for 6800 branch instructions. To use it in the memory display function, type FS and the display 'A' appears prompting for an address. Enter the desired branch address and type GO. The display will return to memory display. If a legal offset was calculated, it will be displayed in both data displays and stored at the proper location. If an offset out of range was calculated, an FF will be displayed in the middle

## 1.5 Operating Procedure (cont'd)

two LEDs and the data in RAM (as displayed in the last two LEDs) will not change. If no RAM is at the displayed address, the offset will be displayed in the middle two LEDs only. To re-enter the monitor from the memory display, type EX and the prompt (=) will appear.

GO : The GO key allows the user to execute his programs. To use, enter the programs starting address and type GO. If any breakpoints have been set, they are placed into the user's program and are removed when a breakpoint is encountered. If the user wishes to abort type EX. If the program is aborted or ends in any other than executing a breakpoint, the breakpoints will not be removed.

EX : The escape key is used to re-enter the monitor from any of the commands or from the user's program. The EX key does not change the breakpoints that have been previously entered.

FS : Special Function Key converts all hex keys, P/L, and T/B to alternate function keys. The P/L key causes the load from tape operation to occur. The T/B key allows breakpoints to be entered. The hex keys are defined by the user who must create a jump address table and place the starting address of that table in UHASH (\$8102); a display '= FS' appears when FS is typed in the prompt mode. The \$ symbol signifies that the number is hexadecimal.

## 1.5 Operating Procedure (cont'd)

FC : Clears the special function mode and removes the 'FS' from the display.

T/B: The Trace/Breakpoint key is used to cause single step traces or for Inserting/Displaying/Deleting breakpoints. The Trace function executes one instruction in a program and displays the registers at the end of execution. The registers may then be modified as desired. The user may trace through all the 6800's instructions including the SWI instruction. When an SWI is encountered, the the Trace continues in the user's software interrupt routines. This enables the user to test his interrupt program by placing a SWI instruction in his program and storing the interrupt address at USWIV (\$8108). Trace also allows the user to trace through a program stored in ROM. To use the Trace function, type RD, enter the address of the instruction in the program counter, and type T/B. The user may trace through as many instructions as are needed. If it is desired to execute the program from the display address, type GO. To return to the monitor type EX.

The breakpoint function allows the user to set up eight breakpoints and it allows the user to edit any breakpoints which already exist. Breakpoint addresses are stored in a sequential table along with the op-code at that address. Breakpoints are entered into the user programs when the GO key is typed and removed when a breakpoint point occurs. If any other method

## 1.5 Operating Procedure (cont'd)

is used to return to the monitor, i.e. a jump, the breakpoints will not be removed. To use the breakpoint function type FS and T/B. If this is the first time into the function, the display will be '0000 0' for no breakpoints. Enter the address of the desired breakpoint and type FS. For example: we wish to place a breakpoint at \$5000. Type FS and T/B. The display is '0000 0', enter \$5000 and depress FS; the display is now '5000 1'. This may be repeated until an '8' is display in the far right side.

To display the breakpoints that have been set, type GO. The breakpoints will be displayed one at a time starting with the first breakpoint entered and will repeat until all the breakpoints have been displayed. When the breakpoint function is re-entered at a later time, the breakpoint that was entered first will be displayed first and the rest will be displayed in the order that they were entered.

To remove a breakpoint, step to the breakpoint that is to be removed with the GO key and type FC. The breakpoint entry is removed from the table, the table is compressed, and the breakpoint count decremented by one. One or all of the breakpoints may be cleared in this way. To clear all the breakpoints, push the RS (reset) key. Breakpoints may be set at any address in RAM memory. Breakpoints can not be used in a program stored in ROM.

## 1.5 Operating Procedure (cont'd)

RD: The register display key allows the user to display and modify the user's registers. To display the program counter, type RD and a display appears. This display breaks down as follows: the first four hex characters are the address in the program counter, the next two are the byte at that address, and PC stands for the program counter. The rest of the registers may be displayed one at a time by pressing the RD key. The registers are displayed in the following order:

Program Counter	(PC)
Index Register	(1d)
Accumulator A	(AA)
Accumulator B	(Ab)
Condition Code Register	(CC)
Stack Pointer	(SP)

The user may trace the instruction indicated by the PC by typing T/B. The next instruction will appear and the user remains in register display. The user may continue execution of his program by typing GO. To return to the monitor, type EX.

In order to better understand the keyboard commands of D3BUG, the following examples are given:

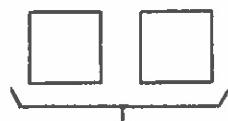
Example 1: Assume you want to examine the contents of address location \$F957.

## 1.5 Operating Procedure (cont'd)

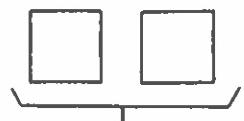
- (1) Enter D3BUG by typing RS. The prompt should appear in the left most display with the remaining displays blank as illustrated.



Address Field



Key Data Field



Read Data Field

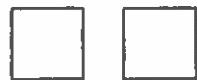
- (2) Type F



- (3) Type 9



- (4) Type 5



- (5) Type 7



- (6) The desired address is now entered, and to display the contents of this address type M.

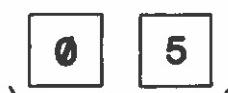


## 1.5 Operating Procedure (cont'd)

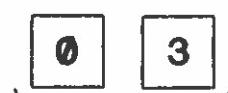
The contents of address F957 will always be 03 because this portion of the address space (see Figure 1.1.1) is the monitor program and it is in ROM. ROM contains permanent data and cannot be altered. To verify this, try to change the data at this location by entering data through the keypad. For example type key 5. The resulting display should be:



Address Field



Key Data Field



Read Data Field

Note that the key data field is a 05. This data should have been written into the address specified by the address field. However, the read data field remained a 03 which meant that this location did not take the keypad data. Had this location taken the data, then the read data field would display a 05 instead of a 03.

Example 2: Using the previous example the GO key function can be examined. With the address and data field given:

F957

03

03

(1) Type GO

F958

7C

7C

The address was incremented by 1 and the data of this address is displayed.

(2) If GO is typed four more times, the resultant address and data fields should be:

## 1.5 Operating Procedure (cont'd)

F959	81	81
F95A	13	13
F95B	FE	FE
F95C	81	81

To examine the contiguous addresses below a selected address, all that is required is to type the M key.

Example 3: Using the address and data of example 1, the display will yield the following results when the M key is typed.

F956	24	24
------	----	----

Hence each time the M key is typed the address will decrement by 1 and the data of the new address displayed.

Typing the M key four more times will yield the following results:

F955	14	14
F954	81	81
F953	67	67
F952	14	14

Example 4: This example will show how to examine and enter data in the user RAM; for this example lets examine the contents of location \$0008.

## 1.5 Operating Procedure (cont'd)

(1) Return to monitor by typing EX.

=								
---	--	--	--	--	--	--	--	--

(2) Type in address 8.

0	0	0	8					
---	---	---	---	--	--	--	--	--

(3) To examine this address, type M.

0	0	0	8	?	?			?	?
---	---	---	---	---	---	--	--	---	---

The two data fields have question marks. The question marks are there, because unless previous data was stored into this address location, the data contents will be unknown. This unknown data state is a result of the storage elements in the RAM, (see Figure 1.1.1) having random data storage on power up.

(4) To store data (for this example use \$8F), first type 8.

0	0	0	8	0	8			0	8
---	---	---	---	---	---	--	--	---	---

(5) Next type F.

0	0	0	8	8	F			8	F
---	---	---	---	---	---	--	--	---	---

Memory location \$0008 will now contain the data \$8F. This data will remain there, until it is purposely changed or power is turned off.

## 1.5 Operating Procedure (cont'd)

Example 5: The following example program is suitable for gaining familiarity with the D3BUG monitor features. The program adds the five values in locations \$10 through \$14 using Accum. A and stores the final results in location \$15. The intermediate total is kept in Accum. A. Accum. B is used as a counter to count down the loop. The Index Register contains a "pointer" (i.e., X contains the address) of the next location to be added. The program, as follows, contains an error which will be used later to illustrate some of D3BUG's features.

In the following listing, the leftmost column contains the memory address where a byte (8 bits) of the program will be stored. The next column contains the machine language op-code and data for a particular microprocessor instruction. The next columns contain the mnemonic representation of the program in assembler format.

```
*  
* Add 5 numbers at locations $10-$14.  
* Put answer in location $15.  
*
```

0020	8E	STRT	LDS #FF	DEFINE STACK IN USER AREA
0021	00			
0022	FF			
0023	4F		CLRA	TOTAL =0

## 1.5 Operating Procedure (cont'd)

0024	C6	LDAB #4	INITIALIZE COUNTER
0025	04		
0026	CE	LDX #10	POINT X TO LOCATION 10
0027	00		
0028	10		
0029	Ab	LOOP ADDA 0,X	ADD 1 LOCATION TO TOTAL
002A	00		
002B	08	INX	POINT X TO NEXT LOCATION
002C	5A	DECB	DONE ALL 5 LOCATIONS?
002D	26	BNE LOOP	BRANCH IF NOT EQUAL
002E	FA		
002F	97	STAA \$15	SAVE ANSWER
0030	15		
0031	7E	JMP PROMPT	GO TO D3BUG PROMPT
0032	F8		
0033	57		

A detailed procedure for entering and debugging this program is shown in the following steps.

1. Start Up and Enter the Program in RAM
  - A. Turn power on. Type the RS button. D3BUG will respond with a (=).
  - B. Type \$0020 followed by the M key. This displays the current contents of location \$0020.

## 1.5 Operating Procedure (cont'd)

- C. Type 8E. This replaces the contents of \$0020 with 8E which is the op-code for the first instruction.
  - D. Type GO. This steps to the next location (\$0021) and displays the contents.
  - E. Type 00.
  - F. Type GO.
  - G. Type next byte of op-code or operand (FF in this case).
  - H. Repeat steps F and G for remaining instructions.
  - I. Type EX. Abort input function.
2. Verify that the program was entered correctly.
    - A. Type 0020M. Location \$20 will be displayed.
    - B. Type GO. Next location will be displayed.
    - C. Repeat step B until done, visually verifying data entered in Step 1.
    - D. Type EX.
  3. Enter data in locations \$10 - \$14.
    - A. Same as 1, except type 0010M to start the sequence. Any data may be entered; however, for purposes of this example 01, 02, 03, 04, and 05 should be entered.
    - B. Type EX.
  4. Verify Data.
    - A. Repeat step 2 except type 0010M to begin the sequence. Verify

## 1.5 Operating Procedure (cont'd)

that the memory contains the values 01, 02, 03, 04, 05 in sequential order.

### 5. Run the Program.

- A. Type EX to insure no other option is active.
- B. Type 0020GO. The program will run down to the "JUMP" instruction at location \$31 which will cause it to go to D3BUG and show (=) on the display.

### 6. Check the Answer.

- A. Type 0015M. (The answer is stored in location \$15). Note that it says \$0A (decimal 10). The correct answer is \$0F or decimal 15; therefore, there is a problem in the program as originally defined. The next steps should help isolate the problem and correct it.

### 7. Breakpoint and Register Display

- A. It might be helpful to see what the program was doing each time it went through the loop. Therefore, set a breakpoint at the beginning of the loop, location \$0029. To do this type EX, FS, and T/B. Next type the address 0029 and then FS.
- B. A breakpoint could also be set at location \$002F. To do this type 2F and then FS.
- C. D3BUG must be told where to begin, so type EX and then 0020GO. The program will run to the breakpoint and then display 0029 Ab. At this point the program is suspended just before location 29

## 1.5 Operating Procedure (cont'd)

and is in D3BUG. On detecting this breakpoint, D3BUG automatically displays the PC and is in the register display mode.

- D. Type RD (go to next register). The display should read 0010. This is the value of the X Register.
- E. Type RD-Display = 00 (A Register).
- F. Type RD-Display = 04 (B Register).
- G. Type RD-Display = F0 (Condition Code Register).
- H. Type RD-Display = 00FF (Stack pointer).
- I. Type RD-Display = 0029 PC. The register display is circular and steps D through H could be repeated.
- J. Type GO (Proceed). Display will show 0029 Ab PC. Once again the registers may be examined.
- K. Type GO (Proceed). Same comment as J.
- L. Type GO (Proceed). Same comment as J.
- M. Type GO (Proceed). Display will now type 002F 97 PC. The program has now successfully completed the loop four times and the A accumulator contains the incorrect sum.

## 8. Correcting the Program.

- A. From above it is evident that although the program was supposed to add five numbers, the loop was executed only four times. Therefore, the LDAB #4 instruction at location \$24 and \$25 should have initialized B to five. There are two approaches to fix the problem; one is temporary, the other is permanent. First the temporary one:

## 1.5 Operating Procedure (cont'd)

- B. Type EX.
- C. Type FS, T/B, then type FC twice and this will clear existing breakpoints.
- D. Type ~~0026~~FS. Set a breakpoint just after B register is loaded.
- E. Type EX.
- F. Type ~~0020~~GO. The program will execute up until ~~0026~~ and then go to the breakpoint routine and, display '~~0026~~ CE PC'.
- G. Type RD three times. This displays the current value in the B accumulator (~~04~~ Ab).
- H. Type ~~05~~. The display will change to ~~05~~ Ab.
- I. Type GO. Program should execute and return to prompt (=).
- J. Type ~~0015~~M. Display = ~~0015~~ ~~0F~~. The program has now calculated the correct value for the addition of the five numbers. This verifies the fix but would be inconvenient to do each time the program was executed. A permanent change would be:
- K. Type EX, FS, and T/B. Then type FC once and this clears existing breakpoints.
- L. Type EX.
- M. Type ~~0025~~M. The display = ~~0025~~ ~~04~~.
- N. Type ~~05~~. The display = ~~0025~~ ~~05~~. This will now permanently change the LDAB #4 instruction to a LDAB #5 instruction.
- O. Type EX.
- P. Type ~~0020~~GO. Execute the program.
- Q. Type EX.

## 1.5 Operating Procedure (cont'd)

- R. Type **0015M**. Display = **0015 0F**, the expected answer; the program is permanently fixed.
- 9. Trace Through the Program.
  - A. Type EX. To trace from the beginning:
  - B. Type FS and T/B. Then type FC as many times as required to remove breakpoints.
  - C. Type FS and T/B. Next type **0020** and then FS. This sets a breakpoint at the first instruction.
  - D. Type EX.
  - E. Type **0020GO** (Go to user program). D3BUG will immediately get the breakpoint and type **0020 8E**.
  - F. Type T/B. The program will execute one instruction and display **0023 4F**. At this point the user can either display the registers by typing RD or continues. To continue:
  - G. Type T/B. GO to next instruction. Display register if desired.
  - H. Continue step G for as long as desired.
  - I. Type EX. Clear trace mode.



## CHAPTER 2

### HARDWARE DESCRIPTION

#### 2.0 Central Processing Unit (CPU)

The MC6802 microcomputer chip is the CPU of the MEK6802D3 computer board. The MC6802 is a 6800 microprocessor with additional features; a clock oscillator circuit and 128 bytes of RAM. This powerful microcomputer chip contains an arithmetic logic unit (ALU), various registers, and control logic. It has a set of 72 different instructions, that include binary and decimal arithmetic logic, shift, rotate, fetch, store, branch interrupt, and stack manipulation. For more detailed information, see the MC6802 data sheet in the appendix. With coded instructions from memory, the MC6802 controls and manipulates address, data, and control information within the system. Thus, the MC6802 is the heart of the MEK6802D3 computer system and interfaces with the rest of the components on the board as illustrated in the system block diagram, Figure 2.0.1.

**SYSTEM BUS:** There are two buses on the computer card; the internal bus that interconnects components on the card and the external or system bus that connects the MEK6802D3 card with the system expansion cards.

The internal bus contains the following signals:

- (1) 16 address lines  
A<sub>0</sub> - A<sub>15</sub>
- (2) 8 data lines  
D<sub>0</sub> - D<sub>7</sub>
- (3) 9 control lines

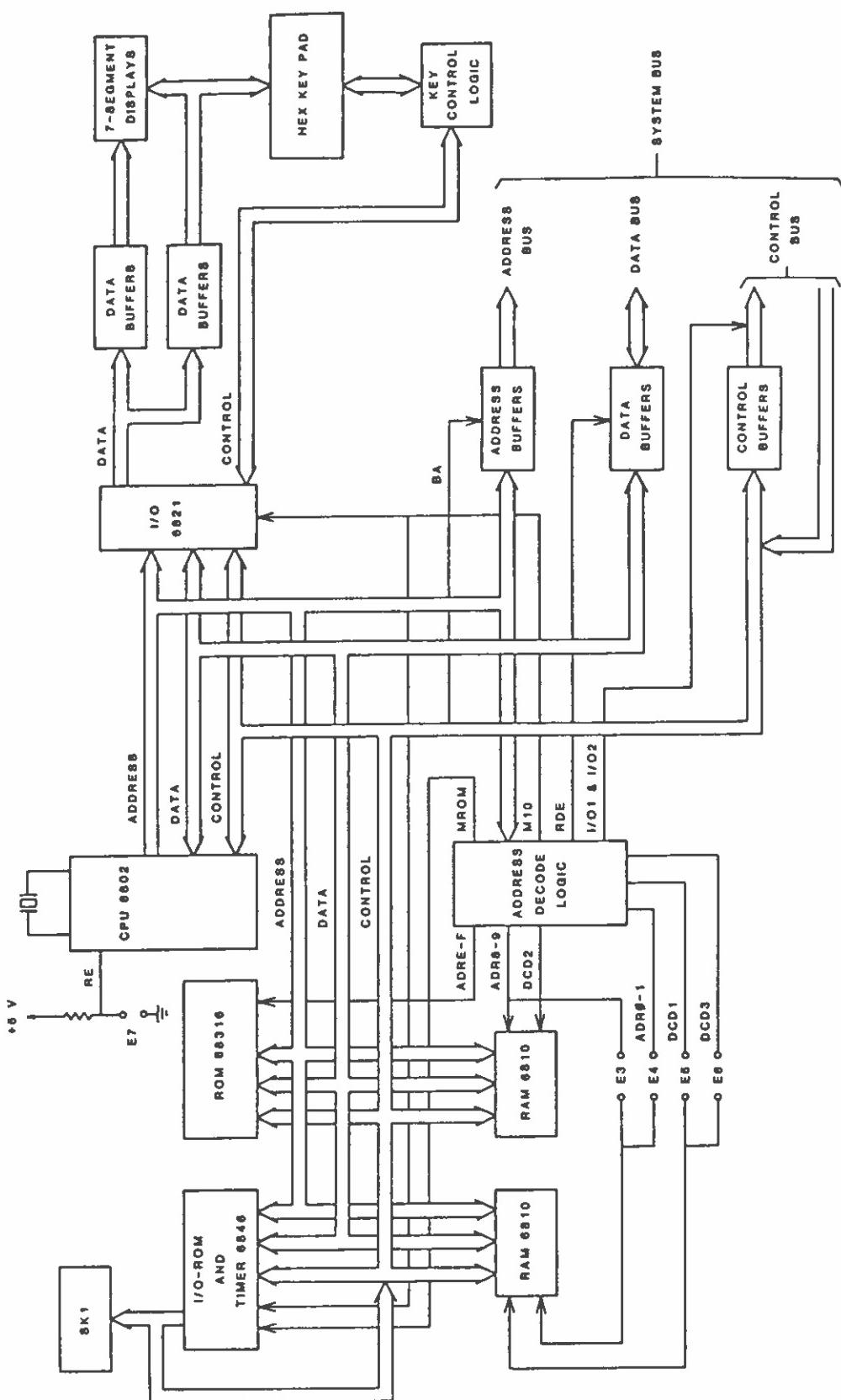


FIGURE 2.0.1. SYSTEM BLOCK DIAGRAM

## 2.0 Central Processing Unit (cont'd)

- (a) E - ENABLE - This signal is the system clock. A standard 3.579545 MHz crystal is used by the processor to generate the 894.8 KHz system clock.
- (b) R/ $\overline{W}$  - Read/Write - This is the read-write control line. Its logic state determines the direction of data (into or out of) a selected chip.
- (c) VMA - Valid Memory Address - This control signal indicates that a valid address is on the address bus.
- (d) MR - Memory Ready - This control signal can cause the E signal to be stretched. When MR is high, E will be in normal operation. When MR is low, E may be stretched an integral multiple of half periods, thus allowing interface to slow devices.
- (e) RESET - this line is used to reset and start the MPU.
- (f) BA - Bus Available - When this signal is active, the MC6802 is stopped and the address bus is available for external devices.
- (g) HALT - When this signal is active, all activity of the MC6802 will be halted.
- (h) IRQ - Interrupt Request - This signal requests that an interrupt sequence be generated within the MC6802.
- (i) NMI - Non-Maskable Interrupt - This signal is similar to IRQ except that the interrupt mask bit in the condition

## 2.0 Central Processing Unit (cont'd)

code register cannot prevent this interrupt from being executed.

A detailed description of these control signals is given in the appendix. The timing relationship of E, R/W, and VMA with respect to address and data signals is shown in the following figure.

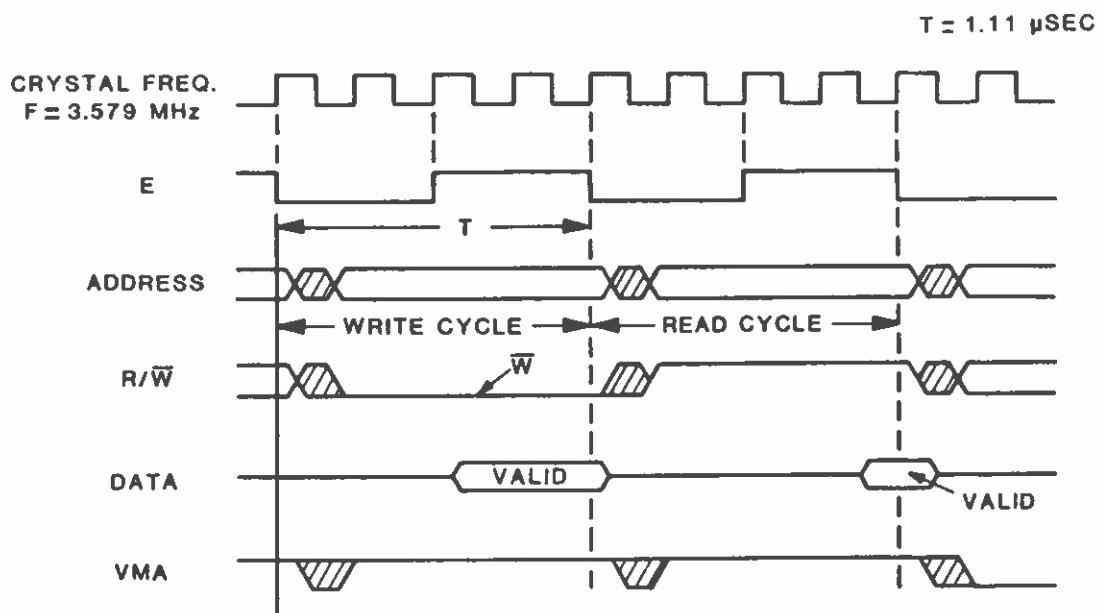


FIGURE 2.0.2. SYSTEM TIMING DIAGRAM

## 2.1 Memory and Address Decode Logic

As mentioned earlier, the MEK6802D3 has two types of memory devices; RAM and ROM.

**RAM:** The on board RAM consists of two MCM6810's that contain 128 bytes each of static storage and 128 bytes located within the MC6802 MPU itself. This random access memory is used for the temporary storage of the user program and variable data.

## 2.1 Memory and Address Decode Logic (cont'd)

The actual location of RAM is determined by the address combination connected to the memory component chip selects. As noted earlier in Figure 1.1.1, the first 128 bytes are located from hex address \$0000 to \$007F. This memory is contained inside the MPU chip and, as illustrated in the address map of Table 2.1.1, does not require any address decoding. Address lines A0 - A6 select one byte out of the possible 128 bytes. If for some reason the user does not want to use the MPU RAM, it can be disabled by placing a jumper in E7; see system schematic (Appendix 3). A jumper in E7 will ground the RAM enable (RE) input and disable the memory from the bus.

The remaining 256 bytes of RAM are obtained with MCM6810 memory chips. Their address locations are determined by the address combination given in Table 2.1.1. The MCM6810 has six chip selects with only three being used for decode; CS0, CS1, and CS2. One MCM6810 (device U30) has the chip selects set to respond to hex address \$0080 to \$00FF. However, as noted in Table 1.1.1 and 2.1.1, the address selection can be moved to hex address \$8180 to \$81FF. This can be accomplished by removing jumpers E4 and E5 and inserting jumpers in E3 and E6.

The other MCM6810 is located at \$8100 to \$817F. This 128 byte block of RAM is employed as stack memory for the D3BUG monitor and should not be used for general purpose storage of user programs.

**ROM:** The MEK6802D3 monitor (D3BUG) is contained in the 2K bytes of ROM of the MC6846. In addition to the ROM, the MC6846 has a bidirectional

TABLE 2.1.1. MEK6802D3 ADDRESS MAP

Device	E	R/ $\overline{W}$	VMA	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0	ADDRESSES	U#
MCM6810	1	*	1	0	0	0	0	0	0	0	0	1	X	X	X	X	X	X	X	0080 - 0FFF	U30
MCM6810	1	*	1	1	0	0	0	0	0	0	0	1	1	X	X	X	X	X	X	8180 - 81FF	U30
MCM6810	1	*	1	1	0	0	0	0	0	0	0	1	0	X	X	X	X	X	X	8100 - 817F	U31
MC68316	1	1	1	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	F000 - F7FF	U29
MC6846	1	1	1	1	1	1	X	X	X	X	X	X	X	X	X	X	X	X	X	F800 - FFFF	U9
MC6846	1	*	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	X	8080 - 8087	U9
MC6821	1	*	1	1	0	0	0	0	0	0	0	1	0	0	0	1	0	X	X	8088 - 808B	U8
MC6802	1	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0000 - 007F	U26

X = Don't Care. • = Both

\* MC6846 ROM.

\*\* MC6846 I/O + Timer.

\*\*\* Inherent to the MC6802 by design; can be disabled for system expansion.

## 2.1 Memory and Address Decode Logic (cont'd)

I/O port and a timer-counter function. The ROM section of the MC6846 is selected with address select lines MROM and MIO. With these select lines, the ROM is enabled for hex address space \$F800 to \$FFFF as given in Table 2.1.1. A detailed description of the software is given in Chapter 4 along with an assembly listing (Appendix 1). It was mentioned in Chapter 1 that to enhance the computer board with additional support boards, would require the D3BUG software to be expanded by another 2K bytes. This expansion ROM (MCM68316 - U29) is located in hex address space \$F000 to \$F8FF. The features of this ROM are given in Chapter 3 and a detailed description and the binary code listing are given in the MEK68R2M manual.

ADDRESS SPACE DECODE: The address space of the computer is fully decoded. There are two 74LS138's (one of eight decoder) that decode address lines A7 through A9 and A13 through A15; see system schematic, (Appendix 3). Table 2.1.2 lists the decoded address space. The three most significant address lines, A13 through A15 are decoded into eight 8K block select lines ADR0-1 thru ADR-F. For hex address space \$0000 to \$1FFF, the decoded select output ADR0-1 will be a logic "0". The other decoded lines will be a logic "1". For address space \$2000 to \$3FFF, select line ADR2-3 will be a logic "0" and so on for the remainder of the select lines.

Address lines A7 through A9 generate the eight decoded select lines DCD0 thru DCD7. Note however from Table 2.1.2 that the decode range

## 2.1 Memory and Address Decode Logic (cont'd)

for the most significant hex digit is not contiguous. That is,  $\overline{DCD0}$  is a logic "0" for the following address ranges:

- (a) \$0000 to \$007F
- (b) \$2000 to \$207F
- (c) \$4000 to \$407F
- (d) \$6000 to \$607F
- (e) \$8000 to \$807F
- (f) \$A000 to \$A07F
- (g) \$C000 to \$C07F
- (h) \$E000 to \$E07F

The reason for this peculiar address range select is that the enable inputs of the 1 to 8 decoder U11 are driven by address lines A10, A11, and  $\overline{A12}$ .

Some of these decoded outputs are logically combined with other address lines or some of the other decode lines, such as  $\overline{ADR8-9}$ , to generate the following decode select lines:

- (a) I/01 - \$8000 to \$807F
- (b) I/02 - \$8080 to \$80FF
- (c) MIO - \$8080 to \$808F
- (d) MROM - \$F800 to \$FFFF

The I/01 and I/02 lines go to the system bus and define the peripheral I/O address range for an expanded system. See Chapter 3 for additional information on these two signals. The decoded address lines are also used for the decode of RAM and ROM.

TABLE 2.1.2. ADDRESS DECODE MAP

Decode Select	E	R/W	VMA	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0	ADDRESS SPACE
ADR0-1	X	X	1	0	0	0	X	X	X	X	X	X	X	X	X	X	X	X	X	0000 - 1FFF
ADR2-3	X	X	1	0	0	1	X	X	X	X	X	X	X	X	X	X	X	X	X	2000 - 3FFF
ADR4-5	X	X	1	0	1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	4000 - 5FFF
ADR6-7	X	X	1	0	1	1	X	X	X	X	X	X	X	X	X	X	X	X	X	6000 - 7FFF
ADR8-9	X	X	1	1	0	0	X	X	X	X	X	X	X	X	X	X	X	X	X	8000 - 9FFF
ADRA-B	X	X	1	1	0	1	X	X	X	X	X	X	X	X	X	X	X	X	X	A000 - BFFF
ADRC-D	X	X	1	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	C000 - DFFF
ADRE-F	X	X	1	1	1	1	X	X	X	X	X	X	X	X	X	X	X	X	X	E000 - FFFF
I/01	X	X	1	1	0	0	0	0	0	0	0	0	X	X	X	X	X	X	X	8000 - 807F
I/02	X	X	1	1	0	0	0	0	0	0	0	0	1	X	X	X	X	X	X	8080 - 80FF
MIO	X	X	1	1	0	0	0	0	0	0	0	0	1	0	0	0	X	X	X	8080 - 808F
MROM	X	X	1	1	1	1	1	X	X	X	X	X	X	X	X	X	X	X	X	F800 - FFFF
DCD0	X	X	X	X	X	X	0	0	0	0	0	0	0	X	X	X	X	X	X	*000 - *07F
DCD1	X	X	X	X	X	X	0	0	0	0	0	0	1	X	X	X	X	X	X	*080 - *0FF
DCD2	X	X	X	X	X	X	0	0	0	0	0	1	0	X	X	X	X	X	X	*100 - *17F
DCD3	X	X	X	X	X	X	0	0	0	0	0	1	1	X	X	X	X	X	X	*180 - *1FF
DCD4	X	X	X	X	X	X	0	0	0	0	1	0	0	X	X	X	X	X	X	*200 - *27F
DCD5	X	X	X	X	X	X	0	0	0	0	1	0	1	X	X	X	X	X	X	*280 - *2FF
DCD6	X	X	X	X	X	X	0	0	0	1	1	0	X	X	X	X	X	X	X	*300 - *37F
DCD7	X	X	X	X	X	X	0	0	0	1	1	1	X	X	X	X	X	X	X	*380 - *3FF

\* = 0, 2, 4, 6, 8, A, C, E (the most significant hex digit can be any of these values).  
X = Don't care.

## 2.1 Memory and Address Decode Logic (cont'd)

### RAM DECODE SELECT

<u>Device</u>	<u>Select</u>	<u>Decoded Address Space</u>
U31	<u>DCD2</u> <u>ADR8-9</u>	\$8100 to \$817F
U30 (Two Address Options)	<u>DCD1</u> <u>ADR0-1</u>	\$0080 to \$00FF
	<u>DCD3</u> <u>ARD8-9</u>	\$8180 to \$81FF or

### ROM DECODE SELECT

<u>Device</u>	<u>Select Lines</u>	<u>Address Space</u>
U9	MROM MIO	\$F800 to \$FFFF
U29	<u>ADRE-F</u> <u>A12</u>	\$F000 to \$F800

Since the above mentioned decoded address space is used for the control of the on board internal data bus (addresses from \$0100 to \$1FFF are to be included in this address space), this memory space cannot be used off board in an expanded system. To insure this, the bidirectional data buffers (U2 and U3) are forced into a data out mode by signal RDE. The above select lines plus the R/W control and E clock are logically combined through gate U27 to insure that RDE will always force the data buffers into an output mode.

If the \$0000 to \$1FFF address space must be utilized in an expanded system, then the following change must be made to the board:

- (a) Remove E9
- (b) Insert E10

2.1 Memory and Address Decode Logic (cont'd)

(c) Insert E7

(d) Change the address of U30 from \$0080 - \$00FF to \$8180 - \$81FF  
by changing the jumpers as noted earlier.

For complete jumper details, see Chapter 3.

2.2 I/O

KEYBOARD/DISPLAY: The keyboard and display connect to the on board bus through U8, the peripheral interface adapter (PIA) MC6821. A scanning technique is used on both the keyboard and display to reduce hardware, power, and cost. Since the operation of this circuitry is controlled by the monitor program, refer to the software description in sections 4.2, 4.3, 4.4 and the system schematic (Appendix 3) to follow the description of the keyboard/display operation.

DISPLAY: The scanning procedure uses PIA lines PB0 through PB7 and the seven segment pattern to be displayed is controlled by PIA lines PA0 through PA6. The display routine called PUT (detailed in section 4.2) controls the display logic in the following manner; first the PUT routine determines which of the eight displays will exhibit the desired data by taking one of the PIA PB lines high. For explanation purposes assume PB7 goes high. Next the PUT routine sends the desired seven segment data from DISBUF to the eight displays, U18 through U25. Since PB7 is high, the selected segments of U18 will be turned on. PB0 through PB6 remain low preventing U19 through U25 from displaying data. Then the PUT routine delays for one millisecond. During this one millisecond, U18 will be

## 2.2 I/O (cont'd)

turned on. Next the PUT routine will select the data pattern to be displayed on U19, which is the next display and PIA bit PB6 will be set and PB7 cleared. This sequence continues until the right most digit, U25, has been selected. Next the program returns to display U18 and the sequence repeats itself. This sequence or refresh rate is sufficient to make the displays appear to be on continuously.

Note that (system schematic, Appendix 3) the PIA lines PB0 through PB7 and PA0 through PA6 are buffered. The buffers U17, U14, U15, U33 and U34 are necessary to supply the high current required by the LED displays.

**KEYPAD:** The keypad has 25 keys that are electrically arranged in four columns by six rows. The reset key (RS) is not decoded and is not part of the row/column matrix; see Appendix 3, sheet 3. Note that the rows of the key matrix are driven by the select display driver buffers U19, U33, and U34. Thus as the PUT routing sequentially selects the displays U20 through U25, the corresponding rows of the key matrix will be selected. The select state is a logic "0" or ground. The four columns of the matrix are connected to NAND gate U26B and the four to one demultiplexer, U28A.

When one of the keys in the matrix is depressed, the output of gate U27B will be forced to a logic "1" when the row buffer that the key is attached to goes low. The logic "1" from U27B causes the PIA U8 to set an NMI interrupt, see section 4.3 for a description of the Keypad/Decode routine. When the keypad interrupt is acknowledged, all of the displays are blanked by storing 00 to the segment or data lines of the displays. Next a routine

## 2.2 I/O (cont'd)

is used to determine the column of the key depressed. This routine sequences PIA lines PB6 and PB7. When the output of the four to one demultiplexer goes low, the PIA PA7 line is driven low. This low on PA7 will tell the routine which column was selected by the binary state of the PB6 and PB7 lines.

Next a row find routine is executed. This routine sequentially drives each one of the PB0 through PB5 lines high until the active row is found. There is a key table that corresponds to the key matrix, so when the row and column address of the depressed key is found, the key table can be accessed and the value of the key loaded into the A accumulator. The reset button does not require decoding because it is tied to the power up reset logic which drives the ~~RESET~~ input of the 6802 directly.

SK1 SOCKET: The MEK6802D3 board has one I/O port available for the user other than the D3 I/O system expansion bus. A 16 pin socket SK1 allows the user to interface to the timer and parallel port of the MC6846. The parallel bidirectional I/O port has functional operational characteristics similar to the B port on the MC6821 PIA. These include 8 bidirectional data lines, P0 through P7, and two handshake lines, CP1 and CP2. The control and operation of these lines are completely software programmable. The PIA timer address space is from \$8080 to \$8087, see Figure 1.1.1.

The timer-counter port is a 16 bit binary counter which under software control may be programmed to count events or measure frequencies and time intervals. It can also be used for square wave generation, single pulses

## 2.2 I/O (cont'd)

of controlled duration, and gated signal interrupts may be generated from a number of conditions selectable by software. The CTO (counter timer output) signal is used by D3BUG software to generate a NMI during single step operation.

## CHAPTER 3

### EXPANSION DESCRIPTION

#### 3.0 Introduction

For those who are interested in having a more versatile and powerful computer, the MEK6802D3 can be easily expanded through the system bus. The D3 can interface directly to the following support cards, which are referred to as the MOKEP series boards:

##### (1) MEK68R2M Programmable CRT Interface.

###### Description:

Software programmable line and character format.

- a) 16 x 32, 16 x 64, or 20 x 80.
- b) User defined format.

###### Display features.

- a) 5 x 7 matrix.
- b) Upper and lower case, full 128 ASCII character set.
- c) Semi-graphic capability with up to 160 x 72 screen resolution and two levels of gray shading.
- d) Complete cursor control.

###### Memory.

- a) MCM68316E (2K pre-programmed ROM) included to expand MEK6802D3 to full 4K operating system.
- b) Designed to accept up to 4K bytes of RAM (eight MCM2114's as screen refresh RAM).
- c) Module supplied with 1K byte of MCM2114 RAM.
- d) System MPU has access to display memory.

### 3.0 Introduction (cont'd)

Interfaces to:

- a) CRT monitor, or
- b) Modified TV set.
- c) 128 character ASCII encoded keyboard.
- d) MEK6802D3

Minimal Power Requirements.

- a) Single 5 volt supply at 1.1 Adc max.
- b)  $\pm$  12 volt from bus routed to keyboard interface socket.
- c) Provision for on board negative 5 volt regulation for keyboard interface socket.

#### (2) MEK6810 Input/Output Module.

Description:

Parallel input/output.

- a) Provisions for two MC6821 PIA's gives total of four 8 bit ports with eight control lines.
- b) One MC6821 furnished with module.

Audio cassette interface.

- a) 300 baud Kansas City Standard.
- b) 1200 baud Modified Kansas City Standard.
- c) Both 300 and 1200 baud fully populated and supported by MEK6802D3 firmware.

Serial input/output.

- a) MC14411 baud rate generator provides all standard communications rates.

### 3.0 Introduction (cont'd)

b) MC6850 ACIA with both RS232C and 20 mA current loop interface.

c) Optically isolated port termination.

IEEE 488 interface.

a) Provisions for user installation of MC68488 and GPIB buffers.

Power requirements.

a) +12 volt utilized by serial I/O only.

b) +5 volt required for all sections.

#### (3) MEK68MM Dynamic Memory Module.

Description:

Hidden refresh operation.

Available in two configurations.

a) 32K byte as MEK68MM32.

b) 16K byte as MEK68MM16.

Low power consumption.

a) VCC (+5 V) requires 820 mA for either 16K bytes or 32K bytes.

b) ± 12 volts.

RAM paging feature fully supported.

#### (4) MEK6802RR ROM/RAM Module.

Description:

Contains two blocks of four ROM/EPROM sockets each.

a) Either block can utilize 1K, 2K, 4K, or 8K byte ROM/EPROM.

b) ROM/EPROM with single or multiple supplies can be used.

c) ROM paging feature supported by each block.

Contains two blocks of eight MCM2114 sockets each.

### 3.0 Introduction (cont'd)

- a) Either block is independently relocatable to any even 4K starting location ( $X000$ , where X = any hex number from 0 - F).
- b) RAM paging feature supported by each block.
- c) Each block has Write disable switch to allow ROM simulation during debug.
- d) Two MCM2114's (1K byte) supplied with module.

Power requirements.

- a) Option on board negative 5 volt regulator for use with EPROM's.
- b) Population options determine current and voltage requirements.

### (5) MEK68VG Color TV Monitor Interface.

Operating modes.

- a) System is operable in alphanumeric, semi-graphic, and full graphic modes.
- b) Internal ROM creates ASCII characters for alphanumeric mode.
- c) Alphanumeric mode displays 32 x 16 character density and has selectable video inverse.
- d) Semi-graphic modes offer 8 colors in 64 x 32 density or 4 colors in 64 x 48 density.
- e) Full graphic mode offers 2 or 4 colors and 64 x 64, 128 x 64, 128 x 96, 128 x 192 or 256 x 192 density.

Memory.

- a) MCM68316E (2K pre-programmed ROM) included to expand MEK6802D3 to full 4K operating system.
- b) Designed to accept up to 6K bytes of RAM (twelve MCM2114's).

### 3.0 Introduction (cont'd)

- c) Module supplied with 1K byte of MCM2114 RAM.
- d) Dual density addressing allows 6K of display with 1K of memory.
- e) System MPU has access to display memory.

Interfaces to:

- a) Color TV Monitor, or
- b) Modified color TV set.
- c) 64 character ASCII encoded keyboard.

Single 5 volt supply.

### (6) MEK68WW Wire Wrap/Extender Card.

Description:

Supports standard 0.3" and 0.6" wide DIP's.

- a) 26 columns with 0.3" spacing.
- b) Each column contains 42 holes with 0.1" spacing.
- c) Provisions for two decoupling capacitors per column.

Bus interface.

- a) Address, Control and Data Bus buffers supplied with board for user installation.
- b) Seventy-pin female connector allows ten user defined signals to be routed to motherboard. (MEK68MB utilizes 70 pin male connector).

Male right angle connector (60 or 70 pin).

- a) Allows use as extender card.
- b) Can be used as cable connector.

Unassembled kit allows user to define configuration.

### 3.0 Introduction (cont'd)

#### (7) MEK68EP EPROM Programmer Module.

##### Description:

Programs wide variety of products.

- a) 1K, 2K or 4K byte EPROM's.
- b) Single 5 volt or multiple supply versions.
- c) Motorola, Intel or TI pinouts.

##### EPROM user sockets.

- a) After programming, up to four EPROM's (or ROM's) can be inserted in on board sockets for system usage.
- b) Sockets fully support ROM paging feature.
- c) Jumper options allow location in User-Defined Address Space.

##### Programming features.

- a) On board DC to DC converter supplies programming voltage.
- b) Firmware provided contains programming routines.
- c) Copy and verify functions incorporated.

##### Two-board construction.

- a) All electronic circuitry contained on standard 7.0" x 8.25" board.
- b) Separate EPROM programming socket module plugs into top of main board, or - with User Supplied Cable - can be remotely located.
- c) EPROM programming socket contains Easy In - Easy Out socket.

##### Power supply requirements.

- a) +5 volts utilized by all components.
- b) +12 volts required if multiple supply EPROM's used.

3.0 Introduction (cont'd)

(8) MEK68CC Card Cage for use with MEK68MB.

All aluminum construction.

Easy 15-minute assembly.

Supplied with connectors to fully expand MEK68MB.

Dimensions of 8-1/4" high x 7-1/4" wide x 13-1/4 deep.

- a) Fits one-half of standard cabinet such as Zero Manufacturing P/N 170822.
- b) Other half free for power supply, mini-floppy, etc.
- c) Extra length provides for mounting of cooling fan or power supply behind motherboard.
- d) Designed for convection or forced air cooling.

(9) MEK68MB Motherboard for MOKEP Series.

Description:

Seventy-pin connectors.

- a) Accept all MOKEP series.
- b) Provide for expansion.

Five slots populated.

- a) Stand-alone card guides permit use without Card Cage.
- b) 1-1/4" spacing between populated slots.
- c) Five additional slots for subsequent upgrade with Card Cage.

Rugged construction.

- a) 0.062" thick epoxy G-10 material.
- b) Aluminum board stiffeners serve as mounting base.
- c) Terminal block for power supply connections.

### 3.0 Introduction (cont'd)

(10) MK68CMB Card Cage and fully populated (10 slot) motherboard.

Description:

Same features as MEK68CC and MEK68MB.

### 3.1 System Configuration.

To expand from the single board computer, the user has several options depending on the use and application. The following examples illustrate some of the possible system configurations; from the small dedicated system to the large and flexible type.

(1) The MEK6802D3 plus:

- (a) MEK68IO
- (b) MEK68MB

This configuration will allow the user to write programs up to 256 bytes and provide permanent program storage through an audio cassette. With the MEK68WW board, this system could be used to control a variety special or unique I/O devices.

(2) The MEK6802D3 plus:

- (a) MEK68IO
- (b) MEK68MB
- (c) MEK68RR

The addition of the MEK68RR can increase the users dynamic programming storage space from 256 bytes to 8,448 bytes. The MEK68RR card also provides the user with ROM storage space that will permit conversion of often used software to permanent storage or firmware.

### 3.1 System Configurations (cont'd)

(3) The MEK6802D3 plus:

- (a) MEK68IO
- (b) MEK68MB
- (c) MEK68MM
- (d) MEK68R2M

A system configured with these boards will also require an ASCII keyboard and TV or monitor. This is a minimal system configuration for those users desiring to write and develop sophisticated software. If colored graphics were desired, then the MEK68VG board would be used instead of the MEK68R2M. Also additional memory cards can be added to accommodate larger software requirements.

For special or custom interface requirements, the MEK68WW can be used. Also, for those applications requiring an enclosure, the all aluminum card cage (MEK68CC) can be employed. This card cage was designed to fit into one-half of a standard cabinet such as Zero Mfg., P/N 178022.

### 3.2 Expanded Memory Address Space.

As mentioned earlier, provisions were made for system expansion to accomodate multi-level memory paging. This is accomplished by using the 8 bit bidirectional data port of the MC6846. Six of the possible eight bits are used: three of the data bits P0 through P2 are buffered (ROP0 - ROP2) and used on the system bus to select one of eight ROM pages, see Figure 3.2.1. The user address space for the eight ROM pages is 20K bytes each.

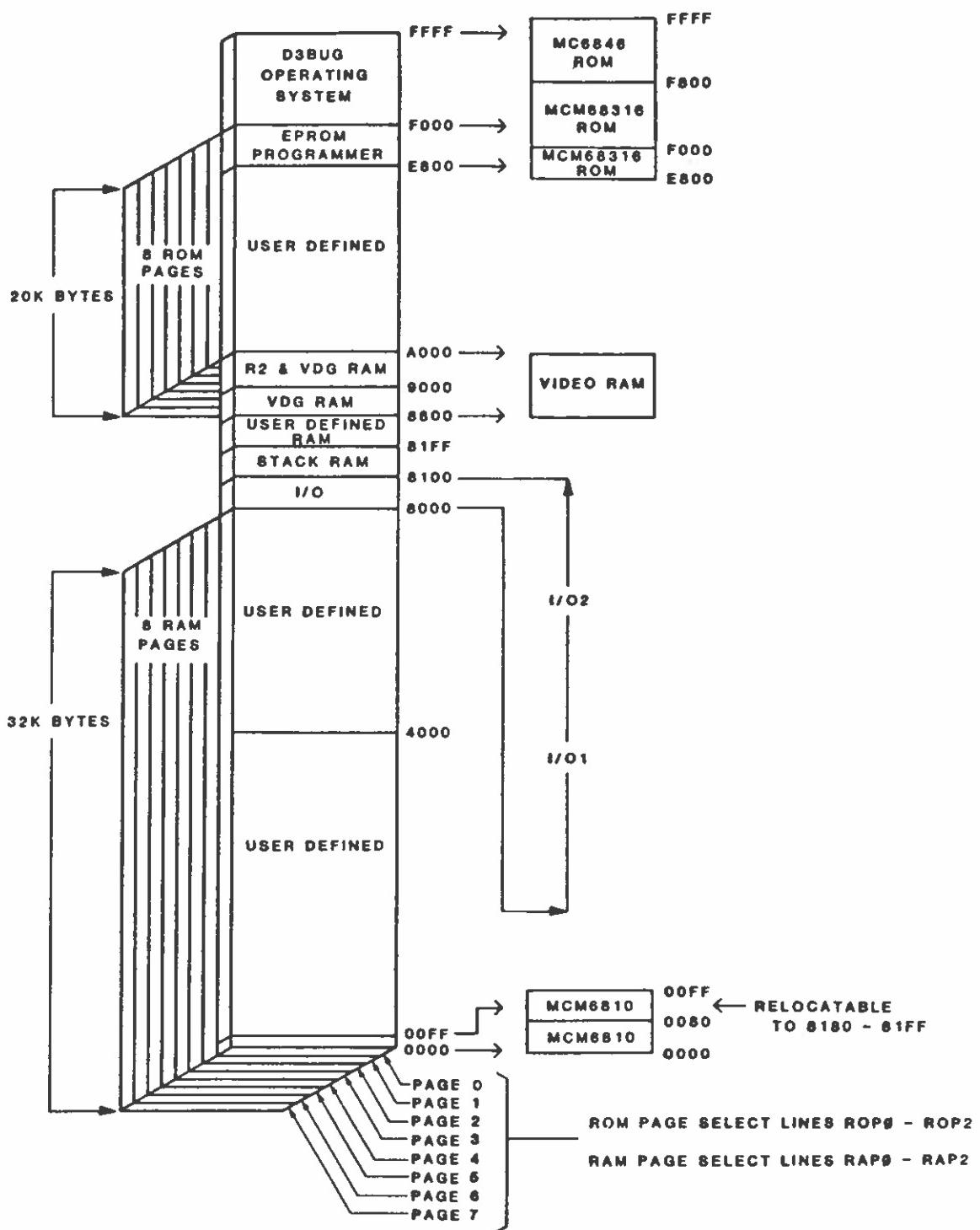


FIGURE 3.2.1. EXPANDED MEK6802D3 MEMORY MAP

### 3.2 Expanded Memory Address Space (cont'd)

The remaining 3 bits, P3 through P5, are also buffered and are used on the system bus for selection of one of eight RAM pages, see Figure 3.2.1. The user address space for eight RAM pages is 32K bytes each. The user has control of the page addresses through software control of the MC6846 PIA port. For detailed information on use and control of the PIA port, consult the MC6846 data sheet in the appendix.

#### 3.2.1 Expansion Firmware Features.

In Chapter 1, (paragraph 1.5) it was mentioned that the D3BUG contained a punch and load function for an audio cassette. To use the following described punch and load routine requires that an MEK68IO board be on the system bus.

P/L: The Punch/Load key is used to punch/load/verify cassette tapes in two different formats and at two different baud rates. One is the 300 baud Kansas City standard and the other is a 1200 baud binary format with check sum. The baud rate is selected on the I/O card by the user.

To punch a tape switch the baud rate selector on the I/O board to either 300 or 1200 baud. Type P/L and the display will prompt with a 'B' for beginning address. Enter the address and type GO. The display will then prompt with an 'E' for ending address. Enter the address and either type GO, for a 1200 baud tape or type FS and then GO for a 300 baud. When finished the display returns with a 'B'. After punching the tape you may verify it by rewinding the tape and either type M to verify a 1200 baud tape or type FS and then M to verify a 300 baud tape. If the tape is

### 3.2.1 Expansion Firmware Features (cont'd)

good, the display returns with a 'B' and the ending address that was entered earlier. If the verify fails, the display returns with a 'B' and the address of the bad byte.

To load a tape, type FS and then P/L. A display '12 3 ?' will appear prompting for either a 1200 baud formatted tape (12) or a 300 baud formatted tape (3). The numbers refer to the baud rate at which the two formats are recorded. To load a 1200 baud tape, place the recorder in its play mode and type G0. To load a 300 baud tape, type FS and then G0.

You may also verify a tape in the Load mode in the same manner described in the Punch mode. However, when the verify fails the display 'CS ?' appears. If the verify passes, then '12 3 ?' appears.

EXPANSION ROM: To accommodate other expansion boards, the D3BUG monitor was enhanced by an additional 2K bytes of code. The 2K expansion ROM, device U29, for the MEK68R2M contains the following features:

- (1) Memory display/change with offset calculation.
- (2) Register, page display/change.
- (3) Breakpoint display/change/delete.
- (4) Trace single/multiple instructions, display registers, stack pointer, program counter, and up to four 16 bit locations selected by the user.
- (5) GO TO user program.
- (6) Continue execution.

### 3.2.1 Expansion Firmware Features (cont'd)

- (7) Punch/load, verify, offset/load 300 or 1200 baud.
- (8) Examine block of memory with ASCII equivalent.
- (9) User defined functions (3).
- (10) RS232 handler.
- (11) Allow paging control.

For details on these additional features, consult the MEK68R2M user manual. The expansion ROM goes in socket U29 on the MEK6802D3 board.

I/O ADDRESS MAP: The address space for the various expansion boards is given in the expanded memory map of Figure 3.2.2. A detailed control and address map for the boards is illustrated in Table 3.2.1. Note that for I/O address continuity, the I/O and timer of the MC6846 and the keypad/display PIA of the MEK6802D3 computer board were included.

## 3.3 I/O Expansion Bus.

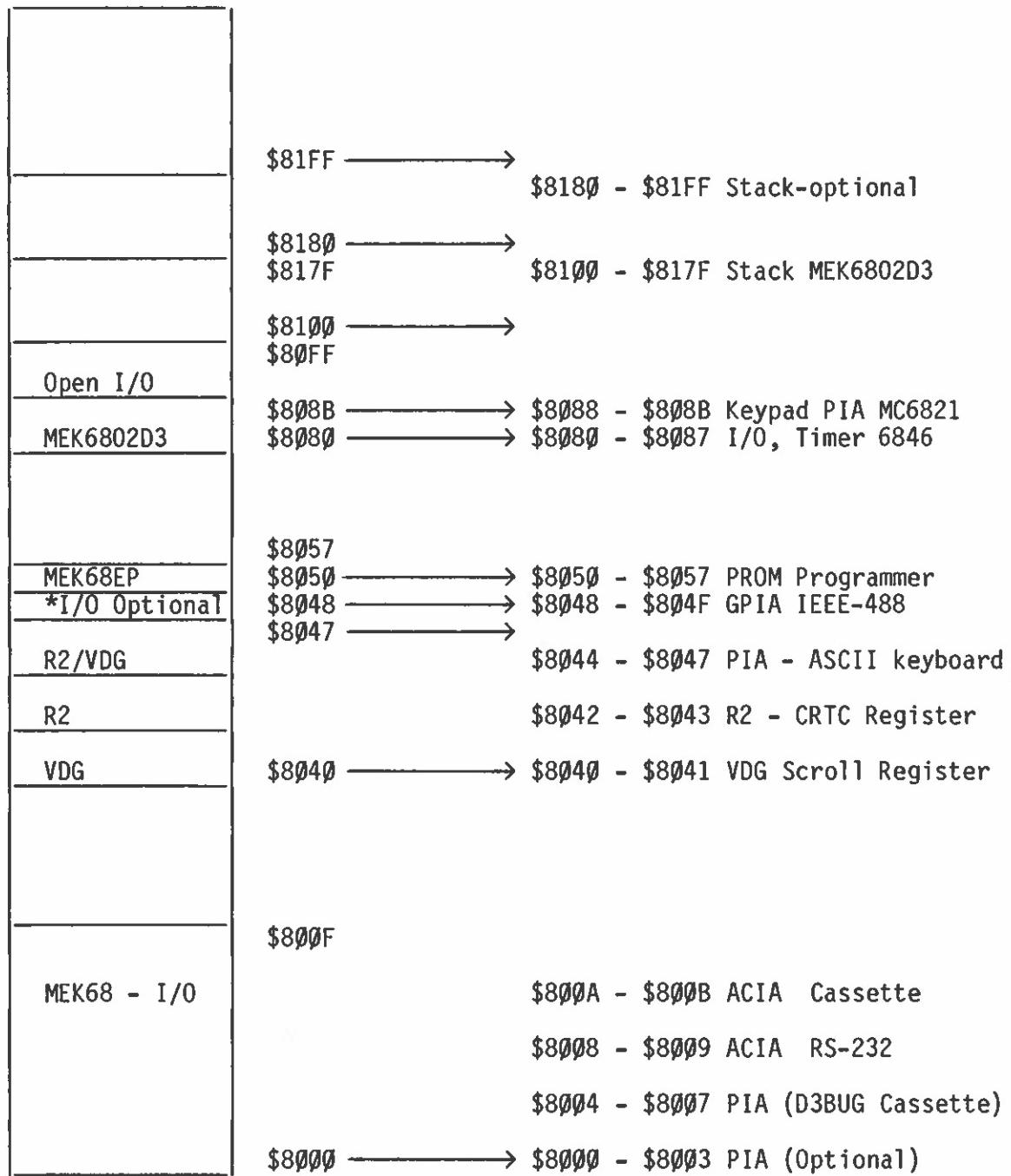
SYSTEM BUS: The external system bus is used to interconnect the various expansion boards to the MEK6802D3 computer board. Table 3.3.1 lists the pinouts of all the signals on this bus.

The external bus contains all of the internal bus as described in section 2.0 plus the following:

- (1) 3 - ROM page select lines (ROP0 through ROP2).

These lines are used to select one of eight possible ROM pages and their logic state is controlled through the user's program; see Figure 3.2.1.

I/O MEMORY MAP: MOKEP



\*See MEK68I0 manual for details.

FIGURE 3.2.2. EXPANDED I/O MEMORY MAP

TABLE 3.2.1. I/O CONTROL AND ADDRESS MAP

Selected Function User PIA	VMA	E	I/01	I/02	A6	A5	A4	A3	A2	A1	A0	Address	Board
User PIA	1	1	1	0	0	0	0	0	0	X	X	8000 - 8003	MEK6810
Cassette PIA	1	1	1	0	0	0	0	0	1	X	X	8004 - 8007	MEK6810
ACIA RS-232	1	1	1	0	0	0	0	1	0	0	0	8008 - 8009	MEK6810
ACIA Cassette	1	1	1	0	0	0	0	0	1	0	1	800A - 800B	MEK6810
*IEEE - 488 GPIO	1	1	1	0	1	0	0	1	0	X	X	8048 - 804F	MEK6810
VG Scroll Register	1	X	1	0	1	0	0	0	0	0	0	8040 - 8041	MEK68VG
R2 - CRTC Register	1	1	1	0	1	0	0	0	0	1	X	8042 - 8043	MEK68R2M
ASCII Key Board/PIA	1	1	1	0	1	0	0	0	0	1	X	8044 - 8047	MEK68R2M
PROM Programmer	1	1	1	0	1	0	1	0	X	X	X	8050 - 8057	MEK68EP
I/O + Timer	1	1	0	1	0	0	0	0	0	X	X	8080 - 8087	MEK6802D3
Keypad/Display PIA	1	1	0	1	0	0	0	0	1	0	X	8088 - 808B	MEK6802D3

\*Circuitry on board only - user supplied parts.

TABLE 3.3.1 MEK6802D3 SYSTEM BUS PIN OUTS

Pin Number	Signal	Pin Number	Signal
1	GND	31	A1
2	E ( $\emptyset 2$ )	32	A2
3	+5 V STBY	33	A3
4	+5 V	34	A4
5	OPEN	35	A5
6	OPEN	36	A6
7	OPEN	37	A7
8	MR	38	A8
9	VMA	39	A9
10	BA	40	A10
11	R/W	41	A11
12	GND	42	A12
13	<u>RESET</u>	43	A13
14	<u>NMI</u>	44	A14
15	<u>IRQ</u>	45	A15
16	HALT	46	GND
17	OPEN	47	GND
18	OPEN	48	D $\emptyset$
19	GND	49	D1
20	KEY SLOT	50	D2
21	ROP $\emptyset$	51	D3
22	ROP1	52	D4
23	ROP2	53	D5
24	RAP $\emptyset$	54	D6
25	RAP1	55	D7
26	RAP2	56	+12 V
27	I/ $\emptyset$ 1	57	GND
28	I/ $\emptyset$ 2	58	-12 V
29	OPEN	59	+5 V
30	A $\emptyset$	60	GND

### 3.3 I/O Expansion Bus (cont'd)

#### (2) 3 - RAM page select lines (RAP0 through RAP2).

These lines are used to select one of eight possible RAM pages and are also controlled through the user's software; see Figure 3.2.1.

#### (3) 2 - I/O select lines.

These decoded lines I/01 and I/02 were described in section 2.1. I/01 select line is a logic "1" for address space 8000 to 807F and a logic "0" for all other address combinations.

I/02 select line is a logic "1" for address space 8080 to 80FF and a logic "0" for all other address combinations. Both the D3BUG monitor and the user's program control the logic state of these lines.

BUS CONTROL: As noted earlier in section 2.0, the MR line is used to allow the MEK6802D3 card to interface with cards that have cycle times slower than the D3. This mode of operation is accomplished by pulling the MR line low, logic "0". When MR is low, clock signal E will be stretched integral multiples of half periods, as noted in Figure 3.3.1, thus allowing interface to slow cards.

BUS ELECTRICAL CHARACTERISTICS: Refer to Table 3.3.2 for the system bus electrical characteristics. The MEK6802D3 can accommodate up to ten standard expansion boards.

JUMPER OPTIONS: The MEK6802D3 board contains numerous jumpers which allow it a great deal of flexibility during system expansion. These

### 3.3 I/O Expansion Bus (cont'd)

TABLE 3.3.2. BUS ELECTRICAL CHARACTERISTICS

Signals	Parameter	Min	Max	Unit (dc)
A <sub>0</sub> - A <sub>15</sub> , ROP <sub>0</sub> - ROP <sub>2</sub> , RAP <sub>0</sub> - RAP <sub>2</sub> , E, VMA, BA, R/W	V <sub>OL</sub> @ I <sub>OL</sub> = +24 mA V <sub>OH</sub> @ I <sub>OH</sub> = -15 mA		0.5	V
D <sub>0</sub> - D <sub>7</sub>	V <sub>OL</sub> @ I <sub>OL</sub> = +24 mA V <sub>OH</sub> @ I <sub>OH</sub> = -15 mA I <sub>IH</sub> @ V <sub>IH</sub> = 2.7 V I <sub>IIL</sub> @ V <sub>IIL</sub> = 0.4 V	2.4	0.5	V
IRQ, HALT, NMI, RESET, MR	I <sub>IH</sub> @ V <sub>IH</sub> = 2.7 V I <sub>IIL</sub> @ V <sub>IIL</sub> = 0.4 V	-7.0	0.2	mA
I/O1, I/O2	V <sub>OL</sub> @ I <sub>OL</sub> = +12 mA V <sub>OH</sub> @ I <sub>OH</sub> = -1.2 mA	2.4	0.4	V

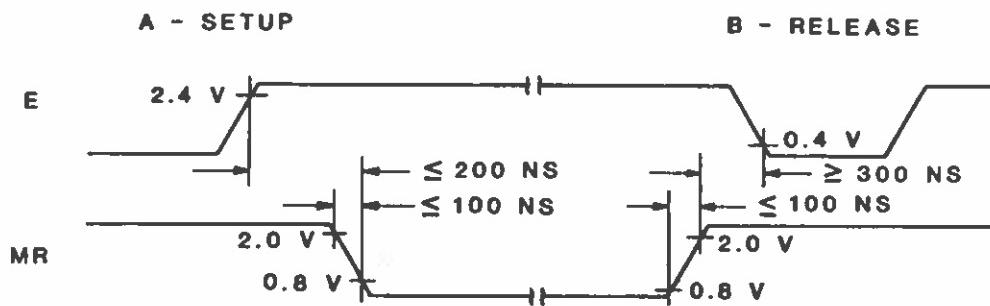


FIGURE 3.3.1. MEMORY READY CONTROL FUNCTION

### 3.3 I/O Expansion Bus (cont'd)

jumpers are actually zero ohm resistors and are given 'E' numbers to denote their locations.

- (A) Jumpers E1 and E2 are used to extend the address range of the MOKEP operating system. The board is configured with E1 removed and E2 installed. This locates signal 'ADDR-F' from \$F000 to \$FFFF. In the other configuration, 'ADDR-F' is extended to \$E000 to \$FFFF. This affects the off board Read Enable 'RDE' signal locking out \$E000 to \$FFFF from being off board. This allows the 'MROM' signal to occupy two locations in the MOKEP Memory Map, \$E800 to \$EFFF and \$F800 to \$FFFF simultaneously.
- (B) Jumper pairs E4-E5 and E3-E6 are used to relocate the MC6810 from \$0080 - \$00FF to \$8180 - \$81FF for use as an auxillary stack. The board is configured with E4 and E5 installed. To reconfigure it, jumpers E3 and E6 should be installed instead. Do not install any other combination, as they will cause the RAM to conflict with other components in the memory map.
- (C) Jumper E7 is used to disable the 128 bytes of RAM located in the MC6802. The board is configured with E7 removed. During system expansion, install E7 which will force RAM enable (RE) low disabling the RAM.
- (D) Jumper E8 does not exist.

### 3.3 I/O Expansion Bus (cont'd)

(E) Jumpers E9-E10 are used to enable or disable reading off board from \$0000 → \$1FFF. The board is configured with E9 installed and E10 removed during system expansion E10 is install and E9 is removed.

#### JUMPER OPTIONS: SUMMARY.

<u>Single Board</u>	<u>Full System Expansion (Note 1)</u>
E1 : Removed	E1 : Removed
E2 : Installed	E2 : Installed
E3 : Removed	E3 : Installed
E4 : Installed	E4 : Removed
E5 : Installed	E5 : Removed
E6 : Removed	E6 : Installed
E7 : Removed	E7 : Installed
E9 : Installed	E9 : Removed
E10 : Removed	E10 : Installed (Note 2)

Note 1 : Including off board RAM module.

Note 2 : A 10K ohm resistor can be used.

## CHAPTER 4

### SOFTWARE DESCRIPTION (D3BUG MONITOR)

#### 4.0 General Description

D3BUG, a 2K x 8 bit monitor program, is provided with the MEK6802D3. It resides in the MC6846, which is a combination ROM, timer and interface port. This chapter provides a description of data storage locations, flow charts of each major section of D3BUG, and a detailed explanation of how to use software routines residing in D3BUG in your own programs. In addition, an assembly listing, complete with a cross-reference symbol listing, is provided in the appendix.

D3BUG requires 128 bytes of RAM memory for its operating stack. This is located from \$8100 to \$817F. This stack RAM is used as temporary data storage for the 6802 processor when a stack operation is required such as a push or pull instruction or when a subroutine or interrupt is encountered.

Several RAM locations are used for temporary data storage and as flags by the monitor for communicating between various routines. Some of the more significant locations are described below and are referred to in the description of D3BUG.

MNPTTR (\$8100)	Contains the address of program to be executed during the PUT routine.
UHASH (\$8102)	User pointer to special function look up.
UNMIV (\$8104)	User non-maskable interrupt vector - store user NMI program address here.
UIRQV (\$8106)	User interrupt request vector.

## 4.0 General Description (cont'd)

USWIV	User software interrupt vector. (\$8108)
DIGEN	Rotating digit enable bit for display. (\$8115)
KEY	Decoded Key value from keypad interrupt. (\$8117)
HEXBUF	4-byte hex buffer for the LED display - 2 digits per byte. (\$8118)
DISBUF	8-byte display buffer (7-segment coded). (\$811C)
USP	User stack pointer. (\$812B)
ROWCOL	Contains the coded key closure derived from the GET routine interrogating a keypad interrupt. (\$812E)
ROLFLG	Flag used by the ROLEN subroutine to indicate to the routine that leading zeros are required when set to zero. If ROLFLG is set to a one, the routine will shift the currently dis- played numbers to the left and store the new value contained in the A accumulator in the rightmost digit. (\$8134)
FLG24	Flag used by the ROLEN subroutine to indicate which displays to update. If FLG24 is set to zero, the update of displays 1-4 is selected; if set to a one the update of display 5-6 is selected. (\$8135)
TOFT	A 2-byte pointer is used by the breakpoint subroutine that holds (\$8140) the current pointer address of the breakpoint table. (\$8140)

## 4.1 Restart/Initialization Routine

The restart/initialization routine is included in the flow chart in Figure 4.1.1. When the RESET (RS) key is released, the 6802 processor outputs addresses \$FFFE and \$FFFF which are the processor's restart vector address locations and contain the program address of RESTRT. This initialization program is located at \$F800, the beginning location of the D3BUG ROM.

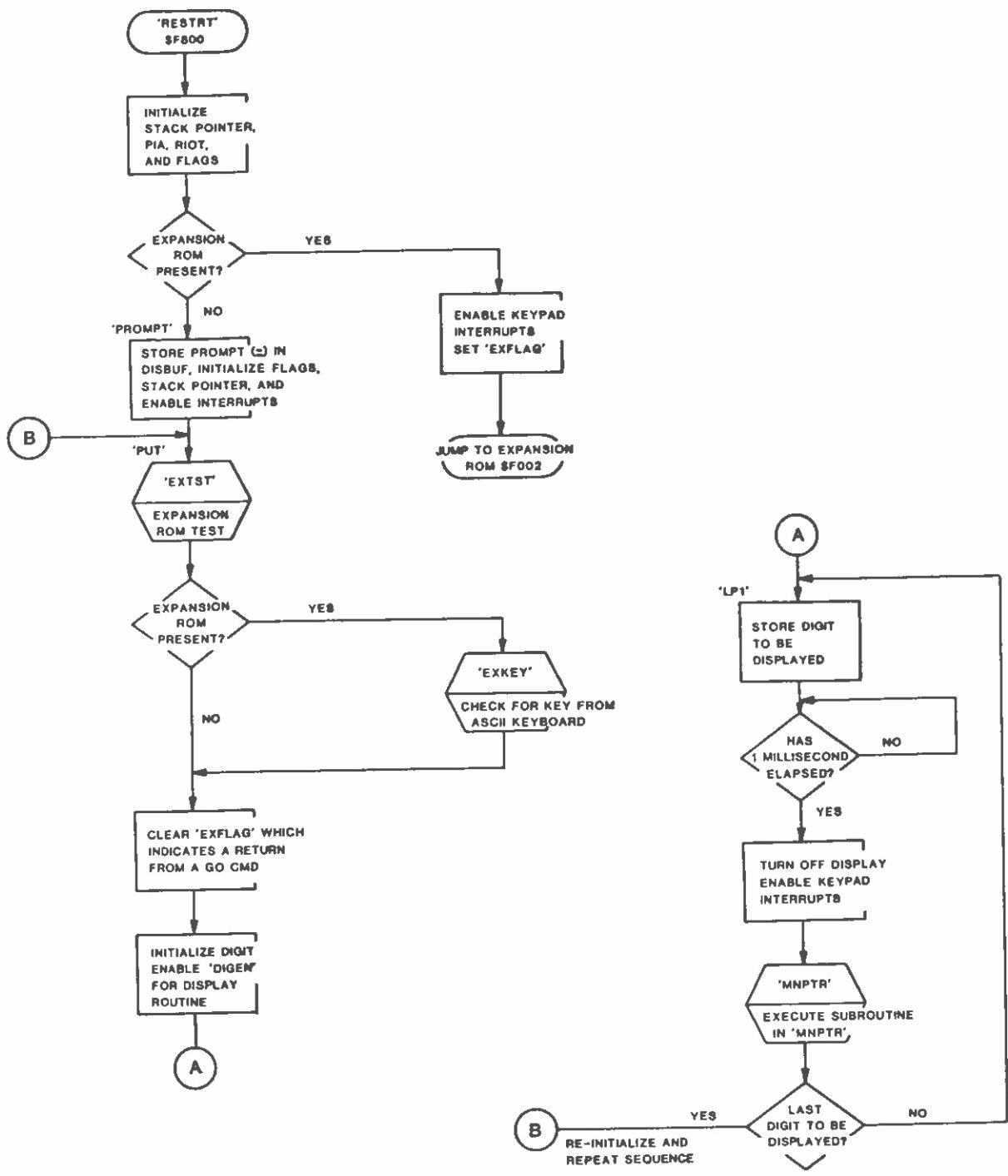


FIGURE 4.1.1. OVERALL PROGRAM FLOW FOR D3BUG MONITOR

#### 4.1      Restart/Initialization Routine (cont'd)

RESTRT initializes the stack pointer to \$817F and sets the interrupt mask to protect against interrupts occurring during initialization. The user stack pointer is initialized to a default address of \$00FF, which is the top of the user RAM supplied with the D3. If it is desired not to relocate the user stack pointer to other than the default address of \$00FF, then do not write programs that would reside in that area of memory.

The next step is the initialization of the timer which is used by the trace command. The fresh start flag (INIT1) is cleared and the top of the table called TOFT is initialized with a \$0B0F which is used in the break-point routine (D3BREAK). The display/keypad PIA, the MC6821 located at \$8080-\$8083; and the memory paging control interface, part of the MC6846 located at \$8088-\$808A are initialized. A subroutine called DISNMI is called to disable the NMI trace timer in order to prevent accidental triggering during initialization.

The program then executes a subroutine that interrogates the presence of an expansion ROM located at \$F000. If the ROM is present, the subroutine that enables keypad interrupts (EFPI) is called and EXFLAG is set to indicate that the expansion ROM is present. The program then jumps to the expansion ROM entry point \$F002. If no expansion ROM is detected, the program exits to the PROMPT routine which continues the initialization sequence.

The subroutine called CLRD clears the 8 LED displays and then the program resets the keypad interrupt flag and displays an equal sign prompt (=)

#### 4.1      Restart/Initialization Routine (cont'd)

on the leftmost display. ROWCOL is initialized to \$80 to indicate there is no key pending and clears other miscellaneous flags. Next the D3BUG stack pointer is again reset to \$817F. Main pointer (MN PTR) is initialized with the address of the D3BUG function decode routine. The subroutine called ENNMI is executed to enable interrupts and control is passed to the routine called PUT.

#### 4.2      Display/Command Execution Routine

The display routine (PUT) is detailed in Figure 4.2.1 and is located at address \$F90B in D3BUG. The PUT routine performs 3 tasks. It is responsible for both updating and multiplexing the LED displays and executing a command subroutine defined by the memory location MN PTR.

The PUT routine begins by checking for the presence of the expansion ROM. If the ROM is detected, it then checks for a key closure from an ASCII keyboard. If a key closure is found, control is turned over to the expansion ROM; otherwise, it returns to the main program flow.

Next the flag called EXFLAG is reset. DIGEN, a temporary byte location used to control the digit enable for the display circuit, is initialized. The next sections of PUT are LP1 and LP2, which are program loops designed to output the contents of the display buffer (DISBUF) to the D3 display LEDs. The display buffer is a temporary storage area of RAM that contains the data for the eight seven-segment displays. LP1 begins by storing DIGEN to the PIA controlling the display. The X register is initialized to point

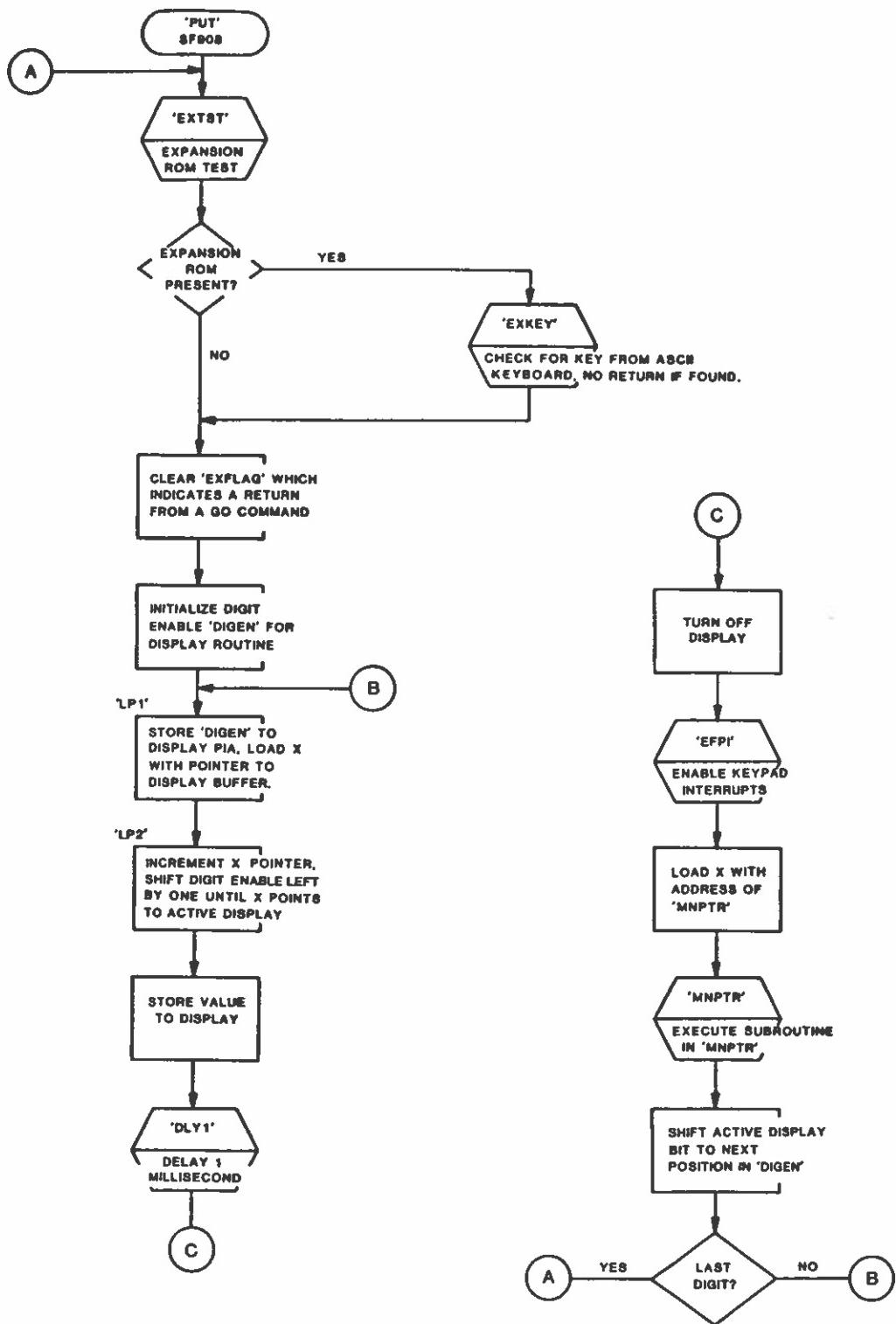


FIGURE 4.2.1. DISPLAY/COMMAND EXECUTION

#### 4.2 Display/Command Execution Routine (cont'd)

to the beginning of the display buffer. LP2 is the internal loop which increments the X pointer by one, until the carry bit is set. The X register is now pointing at the active display. The routine stores the value from the display buffer to the display through the PIA. At this point the program delays for 1 millisecond. This allows the display to be turned on for the length of the delay before blanking and going on to update the next display. The keypad interrupts are enabled through the subroutine called EFPI insuring that a key depression will be recognized. The next step executes the subroutine stored in MNPTR. During restart this location is initialized to point to the function decode routine which detects a key closure, determines the key function and stores the address of the subroutine corresponding to the key function in MNPTR.

The program next shifts the digit select (DIGEN) to the next display position and goes back to LP1 to repeat the process for all eight display positions. When completed, the program returns to the beginning of the PUT routine.

#### 4.3 Keypad/Decode Routine

After receiving a keypad NMI interrupt, the NONMSK routine determines that it is a keypad interrupt and executes the GET subroutine to determine which key was depressed. The GET routine first tests the expansion ROM flag EXFLAG. If an expansion ROM is present, the program exits to the expansion ROM routine called EXGET. If not, the routine blanks all displays by storing a \$00 to the PIA. The COLUMN routine tests each column

#### 4.3 Keypad/Decode Routine (cont'd)

to determine which key is depressed and, when found, the column number is stored in the MSB's of the A accumulator.

The COLFND routine saves the column number and then stores a one in the A accumulator. The ROW routine begins testing each row, shifting the one bit in the A accumulator left by one and looping back through ROW until the active row is found. The ROWFND routine stores the ROW information into the 4 LSB's of the A accumulator, combines the column with the row found, and stores the result in ROWCOL for later. The CLOP routine checks for key release. It continues in a loop until the key is released. The KEYCOD routine massages the row and column data again, this time to form a table offset. The address of the key table is loaded into the X register and the subroutine ADDXA is executed to force the effective table address. The key value is loaded into the A accumulator and saved in KEY for later. The KEYCOD routine then delays for 25 milliseconds. The NMI keypad interrupt is then reset and control returns to the interrupted program.

#### 4.4 Function Decode Routine

The function decode routine (FNCDCD) is used by D3BUG to determine the function of a key depressed. The routine first checks for a key closure. If none is found, FNCDCD returns to PUT. If a key is found then FNCDCD continues with the key value in the A accumulator. If the key is a function key, the appropriate routine corresponding to it is found in a look-up table and the address is stored in MNPTR to be executed later in the PUT routine. The program then returns to the caller. If a hex key is found,

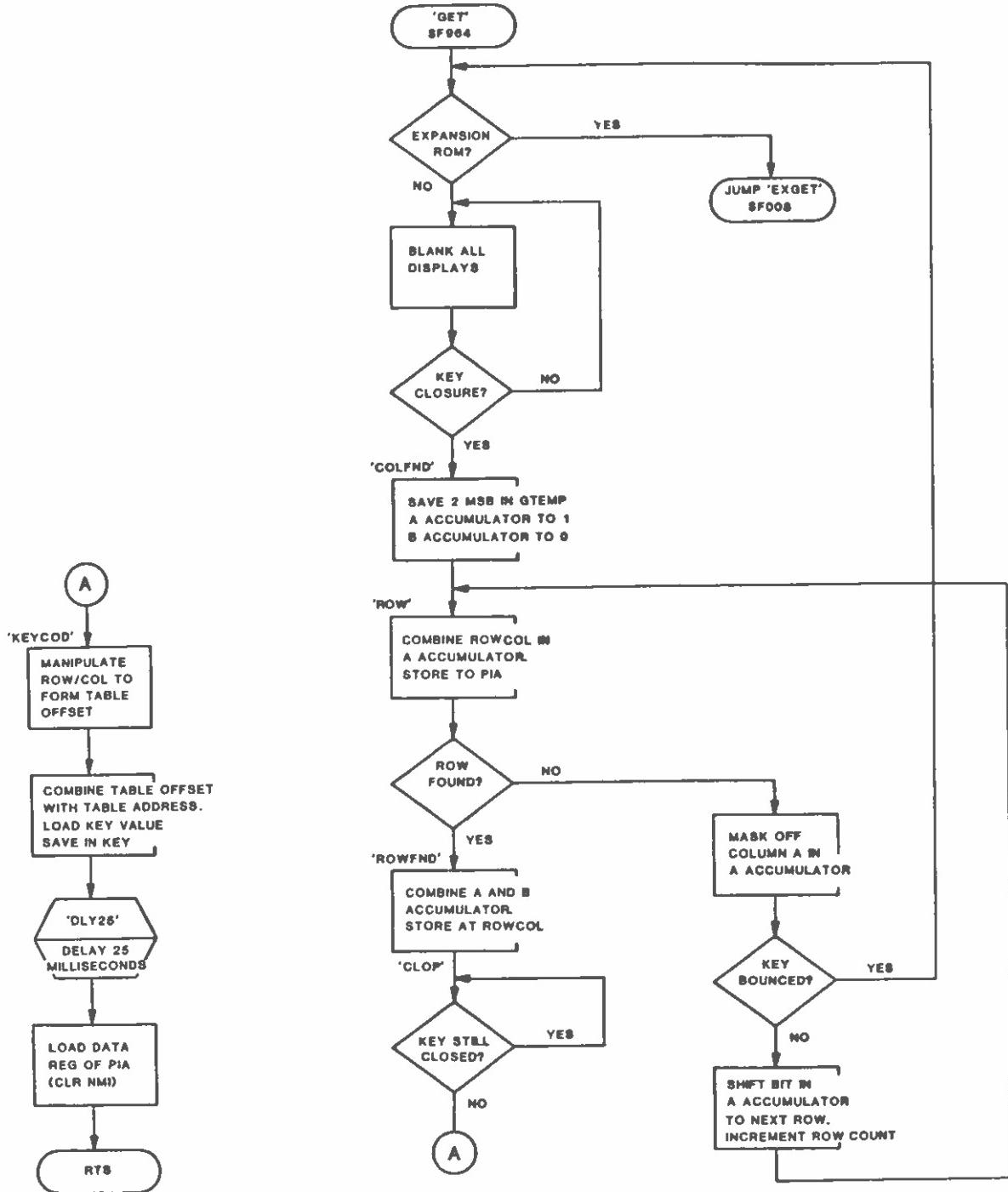


FIGURE 4.3.1. KEYPAD DECODE ROUTINE

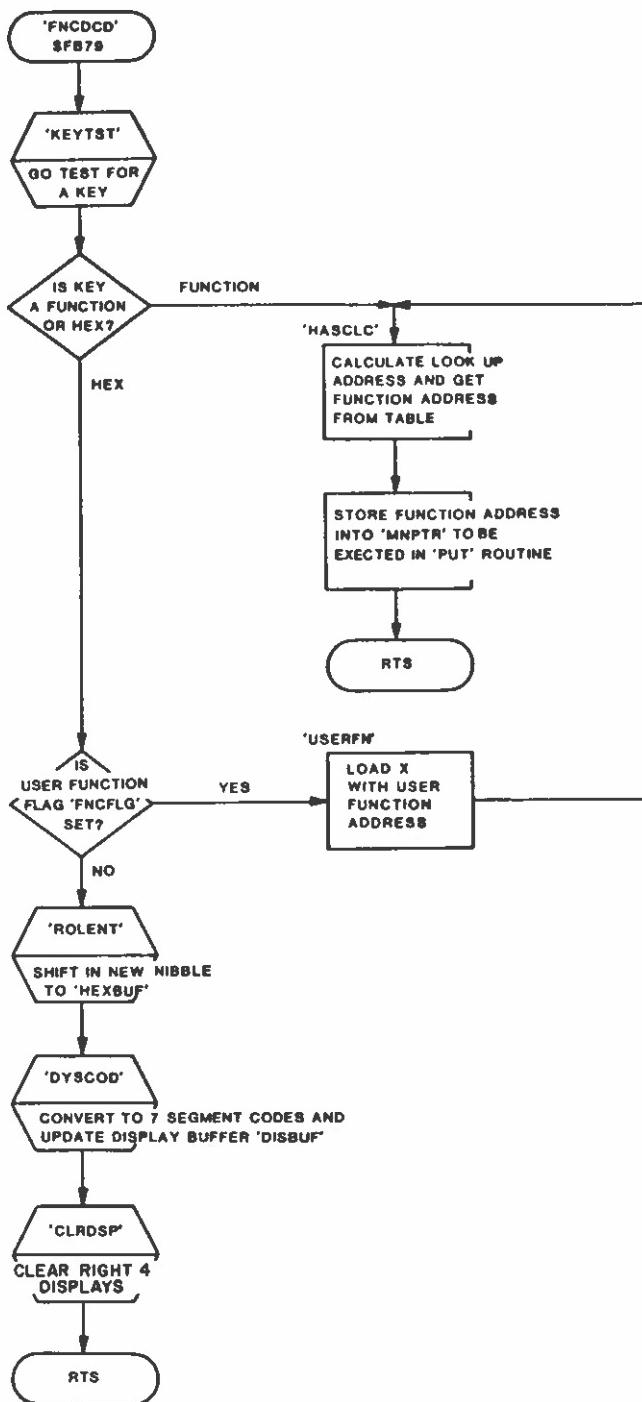


FIGURE 4.3.2. FUNCTION DECODE ROUTINE

#### 4.4 Function Decode Routine (cont'd)

the HEX routine first tests FNCFLG which is set when the user function mode is active. If set, then the user function table address (UHASH) at \$8102 is loaded into X. The HASCLC routine multiplies the key value by 2 and adds it to X to obtain the appropriate function address which is stored into MNPTR to be executed by PUT. If FNCFLG is not set, the routine assumes a valid hex key and calls ROLENT to shift the new value into HEXBUF. The DYSCOD routine is then called to convert the hex data from HEXBUF into seven-segment codes and stores them in DISBUF. The routine calls CLRDSP to clear the right four display digits and then returns to the PUT routine.

#### 4.5 Interrupt Handling Routines

D3BUG handles all three types of 6802 interrupts: Maskable Interrupt Request (IRQ), Non-Maskable Interrupt (NMI), and Software Interrupt (SWI). In handling interrupts, the 6802 completes execution of its current instruction, saves the results on the stack, and then outputs the appropriate vector address. At that address it expects to find the beginning address of the selected interrupt service routine (for more detail, see the MC6802 data sheet in the appendix).

##### 4.5.1 Maskable Interrupt Request

The IRQ interrupt is dedicated for the user. D3BUG handles the interrupt in the following manner. The user places his desired interrupt routine address in RAM at location \$8106. When the interrupt occurs, the routine UIRQ located at \$F95F is executed. This routine loads the contents of

#### **4.5.1 Maskable Interrupt Request (cont'd)**

location \$8106 and jumps to that address. The user must issue an RTI instruction at the end of this routine to return to the interrupted program.

#### **4.5.2 Non-Maskable Interrupt**

The NMI interrupt is used by the MEK6802D3 board to handle both keypad and trace interrupts. D3BUG will also handle user NMI's. A user NMI vector is provided at location \$8104 called UNMIV. If the NMI service routine (NONMSK) determines that the interrupt is not a keypad or trace interrupt, it assumes it to be a user NMI and jumps to the program address stored at \$8104. The user must issue an RTI instruction at the end of his routine to return to the interrupted program.

#### **4.5.3 Software Interrupt**

Software interruptions are used by D3BUG to implement breakpoints (up to a maximum of eight are allowed). D3BUG also permits the user to use the SWI through a vector location at \$8108 called USWIV. The user must issue an RTI instruction at the end of his routine to return to the interrupted program.

### **4.6 User Callable Subroutines**

The majority of the routines written in D3BUG are callable subroutines. This allows them to be used by the expansion ROM or by the user. The following section describes some of the most commonly used subroutines. The D3BUG assembly listing located in the appendix should be referred to if additional explanation is required.

#### 4.6.1 ROLENT

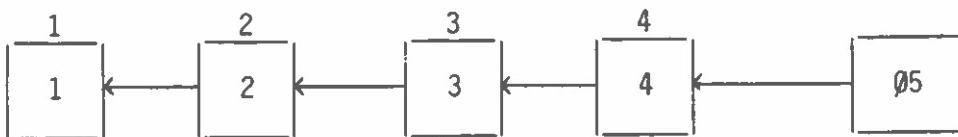
A callable subroutine located at \$FB44 and used for special handling of hex numbers to be displayed in the seven-segment displays. This routine allows the insertion of a new hex digit to the hex display buffer shifting previous digits to the left. The routine can handle a four digit mode for displays 1-4 and a two digit mode for displays 5-6 by the use of FLG24 (located at \$8135). If leading zeros are desired, ROLFLG (located at \$8134) is cleared to zero. The digit to be stored must be stored in the A accumulator upon entry to the subroutine and the B accumulator must be saved if required later by the user. The following example is a user routine to enter a new number to the display.

#### User Program Example

86 05	LDAA	#05	Load 5 into accumulator
7F 8135	CLR	FLG24	Zero for 4 digit mode
7C 8134	INC	ROLFLG	Set to indicate not first entry
BD FB44	JSR	ROLEN	Store 5 in HEXBUF
BD FC0B	JSR	DYSCOD	Convert HEXBUF to display buffer
7E F90B	JMP	PUT	Return to D3BUG control and update display

Current Display

New digit in  
A Accumulator



Results



#### 4.6.2 DYS COD

A callable subroutine, located at \$FC08, which converts HEXBUF (a hex display buffer) into seven-segment values and stores them in DISBUF (the display buffer). DISBUF is used to update the eight seven-segment displays. The user first stores the desired hex digits to be displayed in HEXBUF, which is a four byte buffer located at \$8118 as shown below.

\$8118      HEXBUF      RMB 4

1st Display	2nd Display	1st Byte
3rd Display	4th Display	2nd Byte
5th Display	6th Display	3rd Byte
7th Display	8th Display	4th Byte

Next the user performs a JSR to the DYS COD subroutine. This routine will connect each hex value to its seven-segment value and store it in DISBUF. Upon completion, the program returns to the user. The next several times the PUT routine is executed the values stored in DISBUF are stored to the seven-segment displays.

#### 4.6.3 ADDXA

A callable subroutine, located at \$F94D, which will add the A accumulator to the X register and return to the caller with the new value in the X register with no change to the A or B accumulators.

#### 4.6.4 EFPI

A callable subroutine, located at \$F839, that will enable the keypad interrupts.

#### 4.6.5 EXTST

A callable subroutine, located at \$F83F, that tests for the presence of the expansion ROM by checking address \$F000-1 for a \$55AA. If found the condition code will be set to a zero and returns to the caller. The caller can branch on this condition code.

#### 4.6.6 CLRD

A callable subroutine, located at \$F846, which clears all 8 LED displays by storing an \$00 to each of the DISBUF locations in RAM. Individual displays can be cleared by loading the A accumulator with bits set to indicate which display to clear and entering at \$F848 (CLRDSP). The A accumulator and the X register are destroyed. The Display/Bit representation of accumulator A is shown below.

1	2	3	4	5	6	7	8
Bit							
0	1	2	3	4	5	6	7

LED Displays

#### 4.6.7 DLY, DLY1, DLY25

A callable subroutine, located at \$F949, which provides a means to create calculatable program delays by loading the X register with the delay count, i.e.,  $109_{10} = 1$  millisecond delay. DLY1, located at \$F946 will give a 1 millisecond delay. DLY25 located at \$F941 will give a 25 millisecond delay.

#### 4.6.8 GET

A callable subroutine, located at \$F964, that is used by D3BUG to deter-

#### 4.6.8 GET (cont'd)

mine which key was depressed as a result of an NMI keypad interrupt.

This routine could be used in a users NMI interrupt routine to service a keypad interrupt.

#### 4.6.9 ADDR

A callable subroutine, located at \$FFD8, which subtracts two sixteen bits numbers with the answer stored in the A and B accumulator. To use the routine, first store the subtrahend at locations \$813A (MSB) and \$813B (LSB), then store the minuend at locations \$813C (MSB) and \$813D (LSB).

Upon return from the JSR, the A accumulator holds the MSB and the B accumulator holds the LSB. The X register is destroyed.

#### 4.6.10 DISNMI

A callable subroutine, located at \$F8A4, which disables the keypad non-maskable interrupts. The A accumulator is destroyed.

#### 4.6.11 ENNMI

A callable subroutine, located at \$F8AF, which enables keypad NMI's.

#### 4.6.12 GETIT

A callable subroutine, located at \$FAC4, which interrogates the value in KEY. If the escape function is found, the program jumps to PROMPT; otherwise, the program checks whether the key is a hex or a function key. If a hex key is found, the MPU condition code N is set and the key value is placed in the A accumulator. If a function key is found, the Z condition code is cleared, bits 4-7 of the key value are masked off, and the result is placed in the A accumulator.

#### 4.6.13 IRQ

A callable subroutine, located at \$FFE4, that inputs and outputs to the cassette tape through an ACIA located at \$800A-B.

#### 4.6.14 LOAD

A callable subroutine, located at \$FED3, that loads from an ACIA at \$800A-B, a 1200 baud binary formatted tape.

#### 4.6.15 S300LD

A callable subroutine, located at \$FEFS, that loads from an ACIA located at \$800A-B, a 300 baud K.C. Standard formatted tape.

#### 4.6.16 S1200P

A callable subroutine, located at \$FFB1, that punches a 1200 baud binary formatted tape to ACIA located at \$800A-B.

#### 4.6.17 S300P

A callable subroutine, located at \$FF79, that punches a 300 baud K.C. Standard tape to an ACIA located at \$800A-B.



## **APPENDIX 1**

### **D3BUG 1.0 ASSEMBLY LISTING**



PAGE 001 D3BUG MOTOROLA INC., "MAKING IT HAPPEN IN MEMORY SYSTEMS"

00001 NAM D3BUG  
00002 TTL MOTOROLA INC., "MAKING IT HAPPEN IN MEMORY S  
00003 OPT LLLEN=120,CREF  
00004 \* REV 1.0  
00005 \* COPYRIGHT(C)1979 BY MOTOROLA INC.  
00006 \* MEMORY SYSTEMS "MAKING IT HAPPEN"  
00007 \* AUSTIN, TEXAS  
00008 \* MICROCOMPUTER CAPITAL OF THE WORLD! 3/30/79  
00009  
00010 \*\*\*\*\*  
00011 \*  
00012 \* D3BUG 1.0 COMMAND SUMMARY  
00013 \*  
00014 \*  
00015 \* KEY ADDRESS DESCRIPTION  
00016 \*  
00017 \* M FAE2 COMMAND TO ALLOW MEMORY LOCATIONS  
00018 \* TO BE DISPLAYED AND CHANGED.  
00019 \*  
00020 \* EX F85A ESCAPE-ALLOWS D3BUG REENTRY. DOES  
00021 \* NOT CLEAR BREAKPOINTS.  
00022 \*  
00023 \* RD F9E3 ALLOWS USER TO DISPLAY  
00024 \* AND CHANGE USER REGISTERS.  
00025 \*  
00026 \* GO FC6A GIVES CONTROL TO ADDRESS IN  
00027 \* THE USER PROGRAM COUNTER.  
00028 \*  
00029 \* FS FC52 SETS THE SPECIAL FUNCTION FLAG.  
00030 \*  
00031 \* FC FC5F CLEARS THE SPECIAL FUNCTION FLAG.  
00032 \*  
00033 \* P/L FE22 PUNCH/LOAD/VERIFY 1200/300 BAUD TAPE  
00034 \*  
00035 \*  
00036 \* T/B FC06 ALLOWS DISPLAYING, ADDING, AND  
00037 \* DELETING UP TO 8 BREAKPOINTS.  
00038 \*

00040 \*\*\*\*\*  
00041 \*  
00042 \* D3BUG CALLABLE SUBROUTINES  
00043 \*  
00044 \* ROUTINE ADDRESS DESCRIPTION  
00045 \*  
00046 \* ADDR FFDE SUBTRACTS TWO 16-BIT NUMBERS  
00047 \* STORE IN 813A & 813C AND RETURNS  
00048 \* RESULT IN 'A' & 'B'  
00049 \* RESULT = (813C,813D)-(813A-813B).  
00050 \*  
00051 \* ADDXA F953 ADDS THE A-ACCUMULATOR TO THE  
00052 \* X-REGISTER.  
00053 \*  
00054 \* CLRD F849 CLEARS DIGITS AS INDICATED BY THE  
00055 \* BYTE IN THE A-ACCUMULATOR.  
00056 \*  
00057 \* DISNMI F8A7 DISABLES KEYBOARD NMI'S.  
00058 \*  
00059 \* ENNMI F8B2 ENABLES KEYBOARD NMI'S.  
00060 \*  
00061 \* DLY F94F DELAY LOOP WITH X REGISTER HOLDING  
00062 \* LENGTH OF DELAY  
00063 \* X=\$6D=109=1MILLISECOND  
00064 \*  
00065 \* DLY1 F94C DELAY 1 MILLISECOND  
00066 \*  
00067 \* DLY25 F947 DELAY 25 MILLISECONDS.  
00068 \*  
00069 \* DYSCOD FC11 DECODES 4 HEX BYTES STORED FROM HEXBUF  
00070 \* TO HEXBUF + 3 INTO 7-SEGMENT DISPLAY  
00071 \* CODES WHICH ARE STORED FROM DISBUF TO  
00072 \* DISBUF + 7 FOR DISPLAY.  
00073 \*  
00074 \* EFPI F83C ALLOWS A KEYBOARD INTERRUPT TO OCCUR  
00075 \* WHEN ANY KEY IS PUSHED.  
00076 \*  
00077 \* EXTST F842 LOOKS FOR THE PRESENCE OF \$55AA  
00078 \* AT \$F000. USED TO LOOK FOR AN EXPANSION  
00079 \* ROM.  
00080 \*  
00081 \* GETIT FAC1 READS THE KEYBOARD AND DETERMINES IF  
00082 \* A FUNCTION KEY OR A HEX KEY WAS PUSHED.  
00083 \* RETURNS TO D3BUG PROMPT MONITOR IF EX  
00084 \* KEY IS PRESSED.  
00085 \*  
00086 \* IRQ FFEA INPUTS/OUTPUTS TO THE TAPE ACIA (\$800B)  
00087 \*  
00088 \* LOAD FED9 LOADS FROM A 1200 BAUD FORMATTED TAPE.  
00089 \*  
00090 \* S300LD FEFB LOADS FROM A 300 BAUD FORMATTED TAPE.  
00091 \*  
00092 \* S1200P FFB7 PUNCH A 1200 BAUD FORMATTED TAPE.  
00093 \*  
00094 \* S300P FF7F PUNCH A 300 BAUD FORMATTED TAPE.  
00095 \*  
00096 \* ROLENT FB4A PACKS HEX BYTES INTO ONE OR TWO BYTES.

00099	817F	A	STKTOP EQU	\$817F	TOP OF STACK
00100	8088	A	DISREG EQU	\$8088	PORT A KEYBOARD/DISPLAY PIA
00101	8089	A	DISCTR EQU	\$8089	PORT A CONTROL REG
00102	808A	A	SCNREG EQU	\$808A	PORT B
00103	808B	A	SCNCTR EQU	\$808B	PORT B CONTROL REG
00104	8085	A	TCNTRL EQU	\$8085	6846 CONTROL REG.
00105	8086	A	TMRMSB EQU	\$8086	6846 TIMER REG.
00106	800A	A	ACIA0 EQU	\$800A	CASSETTE CONTROL REG.
00107	800B	A	ACIA1 EQU	\$800B	CASSETTE DATA REG.
00108	F000	A	EXROM EQU	\$F000	EXPANSION ROM STARTING ADDR.
00109	F002	A	EXSTRT EQU	EXROM+2	RESTART JUMP FOR EXPANSION ROM
00110	F005	A	EXREEN EQU	EXSTRT+3	REENTRY JUMP
00111	F008	A	EXGET EQU	EXREEN+3	GET CHARACTER FROM ASCII KEYBOARD
00112	F00B	A	EXPUT EQU	EXGET+3	PUT CHARACTER ON R2 DISPLAY
00113	F00E	A	EXKEY EQU	EXPUT+3	TEST FOR A ASCII KEY PUSHED

00115 \*\*\*\*  
 00116 \*  
 00117 \* D3BUG 1.0 INITIALIZATION SEQUENCE  
 00118 \* BEGINS HERE  
 00119 \*  
 00120 \*\*\*\*

00122A	F800		ORG	\$F800			
00123A	F800	8E	817F	A	RESTRT LDS	\$STKTOP	INITIALIZE STACK POINTER
00124A	F803	0F			SEI		PUT OUT DO NOT DISTURB SIGN
00125A	F804	CE	00FF	A	LDX	*\$00FF	DEFAULT VALUE FOR USER STACK
00126A	F807	FF	812B	A	STX	USP	
00127A	F80A	CE	000E	A	LDX	*\$E	
00128A	F80D	FF	8086	A	STX	TMRMSB	LOAD TIMER WITH LENGTH OF TRACE
00129A	F810	7F	812D	A	CLR	INIT1	FRESH START FLAG
00130A	F813	CE	8143	A	LDX	*BOF	
00131A	F816	FF	8140	A	STX	TOFT	INITIALIZE TOP OF D3BREAK TABLE
00132A	F819	4F			CLRA		
00133A	F81A	B7	8081	A	STAA	\$8081	INITIALIZE PIA
00134A	F81D	43			COMA		
00135A	F81E	B7	8082	A	STAA	\$8082	
00136A	F821	B7	808A	A	STAA	SCNREG	
00137A	F824	44			LSRA		
00138A	F825	B7	8088	A	STAA	DISREG	
00139A	F828	7F	8083	A	CLR	\$8083	INITIALIZE PAGE SELECT TO 0
00140A	F82B	8D	77	F8A4	BSR	DISNMI	
00141	*						
00142			*	LOOK FOR EXPANSION ROM			
00143	*						
00144A	F82D	8D	10	F83F	BSR	EXTST	GO CHECK FOR EXPANSION ROM
00145A	F82F	26	26	F857	BNE	PROMPT	IF NONE, GO ON WITH D3BUG
00146A	F831	8D	06	F839	BSR	EFPI	ELSE,ENABLE KEYPAD INTERRUPTS
00147A	F833	B7	8130	A	STAA	EXFLAG	SET EXPANSION ROM PRESENCE FLAG
00148A	F836	7E	F002	A	JMP	EXSTRT	AND JUMP TO EXPANSION ROM

00150 \*  
 00151 \* SUBROUTINE TO ENABLE KEY PAD INTERRUPTS  
 00152 \*  
 00153A F839 86 3F A EFPI LDAA #\$3F  
 00154A F83B B7 808A A STAA SCNREG  
 00155A F83E 39 RTS \*\*RETURN\*\*

00157 \*  
 00158 \* SUBROUTINE TO CHECK FOR EXPANSION ROM  
 00159 \*  
 00160A F83F FE F000 A EXTST LDX EXROM  
 00161A F842 8C 55AA A CPX #\$55AA  
 00162A F845 39 RTS \*\*RETURN\*\*

00164 \*  
 00165 \* SUBROUTINE TO CLEAR DISPLAY  
 00166 \*  
 00167A F846 86 FF A CLRD LDAA #\$FF CLEAR THEM ALL-  
 00168A F848 CE 811C A CLRDSP LDX #DISBUF OR CLEAR SELECTED DIGITS  
 00169A F84B 44 LOP LSRA WHICH DISPLAYS TO ERASE?  
 00170A F84C 24 02 F850 BCC SKIP11 THOSE WHICH ARE SET IN "A"  
 00171A F84E 6F 00 A CLR 0,X  
 00172A F850 08 SKIP11 INX  
 00173A F851 8C 8124 A CPX #DISBUF+8 LAST DISPLAY?  
 00174A F854 26 F5 F84B BNE LOP NO, CONTINUE CLEARING.  
 00175A F856 39 RTS \*\*RETURN\*\*

00177 \*\*\*\*\*  
 00178 \*  
 00179 \* PROMPT ROUTINE-INITIALIZE DISPLAYS  
 00180 \*  
 00181 \*\*\*\*\*  
 00182A F857 8D ED F846 PROMPT BSR CLRD  
 00183A F859 B6 808A A LDAA SCNREG CLEAR KEY NMI  
 00184A F85C 86 41 A LDAA #\$41 7-SEG CODE FOR PROMPT (=)  
 00185A F85E B7 811C A STAA DISBUF  
 00186A F861 86 80 A PROMPG LDAA #\$80  
 00187A F863 B7 812E A STAA ROWCOL INDICATE NO KEY PENDING  
 00188A F866 CE 812F A LDX NFLAG  
 00189A F869 6F 00 A LOOP1 CLR 0,X  
 00190A F86B 08 INX  
 00191A F86C 8C 8138 A CPX #INIT2+1  
 00192A F86F 26 F8 F869 BNE LOOP1  
 00193 \*  
 00194 \* INITIALIZE FLAGS ETC.  
 00195 \*  
 00196A F871 8E 817F A PROMP1 LDS #STKTOP INITIALIZE STACK POINTER  
 00197A F874 CE FB79 A LDX #FNCDOD GET FUNCTION DECODE ADDRESS  
 00198A F877 FF 8100 A STX MNPTR INITIALIZE 'MAIN' POINTER  
 00199A F87A 8D 33 F8AF BSR ENNMI ENABLE KEYPAD NMI'S  
 00200A F87C 7E F90B A JMP PUT BEGIN EXECUTION

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00202 ****
00203 *
00204 * NMI INTERRUPT ENTRY POINT
00205 *
00206 ****
00207A F87F 86 B3 A NONMSK LDAA *$B3 PRESET TIMER
00208A F881 B7 8085 A STAA TCNTRL
00209A F884 4F CLRA
00210A F885 B7 8088 A STAA DISREG TURN OFF LEDS
00211A F888 B6 8089 A LDAA DISCTR CHECK TRACE INTERRUPT FLAG
00212A F88B 2B 3F F8CC BMI CONTIN IF TRACE, GO TO TRACE ROUTINE
00213A F88D 8D 15 F8A4 BSR DISNMI
00214A F88F B6 808B A LDAA SCNCTR CHECK KEY INTERRUPT
00215A F892 2B 05 F899 BMI KEYNMI IF KEY NMI, GO TO KEY ROUTINE
00216A F894 FE 8104 A LDX UNMIV ELSE, MUST BE USER NMI-GET VECTOR
00217A F897 6E 00 A JMP 0,X AND GO TO USER ROUTINE
00218A F899 7D 8130 A KEYNMI TST EXFLAG
00219A F89C 26 B9 F857 BNE PROMPT
00220A F89E BD F964 A JSR GET GO GET & DECODE THE KEY VALUE
00221A F8A1 8D 0C F8AF BSR ENNMI ENABLE INTERRUPTS
00222A F8A3 3B RTI **INTERRUPT SEQUENCE DONE**

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00224 *
00225 * SUBROUTINE TO DISABLE KEYPAD NMI'S
00226 *
00227A F8A4 86 3E A DISNMI LDAA *$3E CB1 RISING EDGE TRIGGER
00228A F8A6 B7 808B A NMIX STAA SCNCTR PORT B CONTROL REG
00229A F8A9 88 02 A EORA #2 CA1 FALLING EDGE TRIGGER
00230A F8AB B7 8089 A STAA DISCTR PORT A CONTROL REG
00231A F8AE 39 RTS **RETURN**

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00233 *
00234 * SUBROUTINE TO ENABLE KEYPAD NMI'S
00235 *
00236A F8AF 86 3F A ENNMI LDAA *$3F
00237A F8B1 20 F3 F8A6 BRA NMIX EXIT WILL OCCUR THERE

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00239 ****
00240 *
00241 * SOFTWARE INTERRUPT ENTRY POINT
00242 *
00243 ****
00244A F8B3 30 SWINT TSX
00245A F8B4 A6 06 A LDAA 6,X
00246A F8B6 80 01 A SUBA #1
00247A F8B8 B7 8119 A STAA HEXBUF+1
00248A F8BB A6 05 A LDAA 5,X
00249A F8BD 82 00 A SBCA #0
00250A F8BF B7 8118 A STAA HEXBUF SAVE MEMORY LOCATION FOR FNDBRK
00251A F8C2 BD FD88 A JSR FNDBRK
00252A F8C5 27 05 F8CC BEQ CONTIN IF NORMAL BRKPT, GO TO BRKPT ROUTIN
00253A F8C7 FE 8108 A LDX USWIV ELSE, GET USER SWI VECTOR
00254A F8CA 6E 00 A JMP 0,X & GIVE CONTROL TO HIS ROUTINE
00255A F8CC CE 8124 A CONTIN LDX #UCC POINT AT USER REG STORAGE AREA
00256A F8CF 32 LOOP10 PULA GET STACKED USER REG VALUE
00257A F8D0 A7 00 A STAA 0,X PUT IN CORRECT LOCATION
00258A F8D2 08 INX
00259A F8D3 8C 812B A CPX #UCC+7 SEE IF DONE
00260A F8D6 26 F7 F8CF BNE LOOP10 IF NOT, CONTINUE
00261A F8D8 BF 812B A STS USP SAVE USER'S STACK POINTER
00262A F8DB 8E 817F A LDS #STKTOP PUT STACK BACK TO D3BUG STACK
00263A F8DE 7F 8132 A CLR INIT FIRST PASS FLAG USED BY REGDIS
00264A F8E1 B6 812F A LDAA NFLAG IN TRACE MODE?
00265A F8E4 47 ASRA
00266A F8E5 25 14 F8FB BCS TRCE YES, A TRACE HAS OCCURRED
00267A F8E7 BD FDFD A BKP JSR RMBKPT NO, MUST BE A BRKPT-REMOVE IT
00268A F8EA FE 8129 A LDX UPC
00269A F8ED 09 DEX
00270A F8EE A6 00 A LDAA 0,X
00271A F8F0 81 3F A CMPA #$3F
00272A F8F2 26 03 F8F7 BNE ARND1
00273A F8F4 FE 8108 A LDX USWIV
00274A F8F7 FF 8129 A ARND1 STX UPC
00275A F8FA 4F CLRA
00276A F8FB CE F9DD A TRCE LDX *REGDIS REGISTER DISPLAY IS DEFAULT
00277A F8FE 48 ASLA RETURN SIGN BIT-CLEAR TRACE FLAG
00278A F8FF 2A 04 F905 BPL MAIN
00279A F901 4F BKPCNT CLRA CLEAR ALL FLAGS
00280A F902 CE FC64 A LDX *GO CONTINUE EXECUTING PROGRAM
00281A F905 B7 812F A MAIN STAA NFLAG SET FLAGS
00282A F908 FF 8100 A STX MNPTR PROGRAM DESIRED TO RUN

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00284 *****
00285 *****
00286 * PUT ROUTINE USED TO DISPLAY NUMBERS
00287 * AND GO TO DESIRED COMMAND ROUTINE
00288 *****
00289 *****
00290A F90B BD F83F A PUT JSR EXTST EXPANSION ROM PRESENT?
00291A F90E 26 03 F913 BNE PUT2 NO, CONTINUE NORMAL OPERATION
00292A F910 BD F00E A JSR EXKEY CHECK FOR AN ASCII KEY
00293A F913 7F 8130 A PUT2 CLR' EXFLAG CLEAR THE RETURN FROM "GO" FLAG
00294A F916 86 80 A LDAA #$80
00295A F918 B7 8115 A STAA DIGEN INITIALIZE DIGIT ENABLE WORD
00296A F91B B6 8115 A LP1 LDAA DIGEN
00297A F91E B7 808A A STAA SCNREG STORE IT TO PIA
00298A F921 CE 811B A LDX #DISBUF-1 POINT AT DISPLAY
00299A F924 08 LP2 INX
00300A F925 48 ASLA
00301A F926 24 FC F924 BCC LP2 POINT X-REG AT ACTIVE DISPLAY
00302A F928 A6 00 A LDAA 0,X GET VALUE TO BE DISPLAYED
00303A F92A B7 8088 A STAA DISREG STORE TO DISPLAY
00304A F92D 8D 17 F94E BSR DLY1 DELAY 1 MS.
00305A F92F 7F 8088 A CLR DISREG TURN OFF DISPLAY
00306A F932 BD F839 A JSR EFPI
00307A F935 FE 8100 A LDX MNPTR GET ADDRESS IN "MAIN"
00308A F938 AD 00 A JSR 0,X EXECUTE COMMAND SUBROUTINE
00309A F93A 74 8115 A LSR DIGEN SHIFT ACTIVE DISPLAY BIT
00310A F93D 26 DC F91B BNE LP1 CONTINUE TILL BIT FALLS IN CARRY
00311A F93F 20 CA F90B BRA PUT REINITIALIZE DIGEN-CONTINUE
00312 *****
00313 * DELAY SUBROUTINE
00314 *****
00315A F941 CE 0AEA A DLY25 LDX #2794 25 MS ENTRY POINT
00316A F944 20 03 F949 BRA DLY
00317A F946 CE 006D A DLY1 LDX #109 1 MS ENTRY POINT
00318A F949 09 DLY DEX
00319A F94A 26 FD F949 BNE DLY LOOP TILL X EQUAL ZERO
00320A F94C 39 RTS *** RETURN ***
00321 *****
00322 * SUBROUTINE WHICH DOES X=X+A
00323 *****
00324A F94D FF 8113 A ADDXA STX XCALC PUT X-REG IN RAM
00325A F950 BB 8114 A ADDA XCALC+1 ADD A-REG TO LOW BYTE OF X
00326A F953 B7 8114 A STAA XCALC+1 UPDATE LOW BYTE
00327A F956 24 03 F95B BCC ARND IF NO CARRY YOU'RE DONE
00328A F958 7C 8113 A INC XCALC COMPENSATE FOR OVERFLOW
00329A F95B FE 8113 A ARND LDX XCALC LOAD X-REG WITH X+A
00330A F95E 39 RTS *** RETURN ***
00331 *****
00332 * USER IRQ ENTRY ROUTINE
00333 *****
00334A F95F FE 8106 A UIREQ LDX UIREQV
00335A F962 6E 00 A JMP 0,X GIVE CONTROL TO USER IRQ PROGRAM

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00337 *****
00338 *
00339 * GET ROUTINE TO DETERMINE WHICH KEY PRESSED
00340 *
00341 *****
00342A F964 7D 8130 A GET TST EXFLAG EXPANSION ROM PRESENT?
00343A F967 2F 03 F96C BLE GET1 NO, CONTINUE NORMAL OPERATION
00344A F969 7E F008 A JMP EXGET ELSE, GO TO EXPANSION ROM
00345A F96C CE 8088 A GET1 LDX #DISREG POINT AT PIA
00346A F96F 86 3F A LDAA #$3F
00347A F971 A7 02 A COLUMN STAA 2,X TURN ON ALL ROWS
00348A F973 6D 00 A TST 0,X CHECK FOR KEY CLOSURE
00349A F975 2A 08 F97F BPL COLFND IF KEY FOUND, GET COLUMN *
00350A F977 A6 02 A LDAA 2,X
00351A F979 8B 40 A ADDA #$40
00352A F97B 24 F4 F971 BCC COLUMN KEEP TRYING TILL SURE NO KEY CLOSE
00353A F97D 20 E5 F964 BRA GET
00354A F97F 84 C0 A COLFND ANDA #$C0 KEEP ONLY COLUMN *
00355A F981 B7 810A A STAA GTEMP SAVE FOR REFERENCE
00356A F984 86 01 A LDAA #1 PREPARE TO SCAN ROWS
00357A F98E 5F CLRB START ROW COUNT
00358A F987 BA 810A A ROW ORAA GTEMP COMBINE ROW & COLUMN
00359A F98A A7 02 A STAA 2,X STORE TO PIA
00360A F98C 6D 00 A TST 0,X CHECK FOR CLOSURE
00361A F98E 2A 0A F99A BPL ROWFND BRANCH IF ROW FOUND
00362A F990 84 3F A ANDA #$3F MASK OFF COLUMN
00363A F992 81 20 A CMPA #$20 MAKE SURE ROW NOT EXCEEDED
00364A F994 27 CE F964 BEQ GET KEY BOUNCED; KEEP LOOKING
00365A F996 48 ASLA PREPARE TO LOOK AT NEXT ROW
00366A F997 5C INCB INCREMENT ROW COUNT
00367A F998 20 ED F987 BRA ROW LOOP TILL ROW FOUND
00368A F99A 44 ROWFND LSRA RIGHT JUSTIFY COLUMN
00369A F99B 44 LSRA
00370A F99C 84 F0 A ANDA #$F0 MASK OFF LEFT NIBBLE FOR ROW
00371A F99E 1B ABA CONCATENATE COLUMN/ROW
00372A F99F B7 812E A STAA ROWCOL SAVE RESULT
00373A F9A2 6D 00 A CLOP TST 0,X SEE IF KEY STILL CLOSED
00374A F9A4 2A FC F9A2 BPL CLOP STAY IN LOOP TILL KEY GOES AWAY
00375A F9A6 16 KEYCOD TAB COPY ROW/COLUMN INFO
00376A F9A7 C4 07 A ANDB #$07 MASK OFF ALL BUT COLUMN
00377A F9A9 84 30 A ANDA #$30 MASK OFF ALL BUT ROW
00378A F9AB 44 LSRA MOVE ROW OVER AGAINST COLUMN
00379A F9AC 1B ABA COMBINE TO FORM TABLE OFFSET
00380A F9AD CE F9BF A LDX #KEYTBL POINT AT TOP OF TABLE
00381A F9B0 BD F94D A JSR ADDXA FORM ADDRESS OF LOOK-UP DATA
00382A F9B3 A6 00 A LDAA 0,X GET CODE FOR KEY VALUE
00383A F9B5 B7 8117 A STAA KEY STORE VALUE FOR USE BY OTHERS
00384A F9B8 BD F941 A JSR DLY25 DELAY 25 MS TO DEBOUNCE KEY
00385A F9BB F6 808A A LDAB SCNREG RESET NMI ON THE PIA
00386A F9BE 39 RTS ** RETURN **
00387 * MSB OF ROWCOL IS SET IF NO KEY

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00389 \*  
00390 \* KEY DECODE LOOK-UP TABLE  
00391 \*  
00392A F9BF 00 A KEYTBL FCB \$00 '0'  
00393A F9C0 01 A FCB \$01 '1'  
00394A F9C1 04 A FCB \$04 '4'  
00395A F9C2 07 A FCB \$07 '7'  
00396A F9C3 14 A FCB \$14 'FS' FUNCTION SET  
00397A F9C4 10 A FCB \$10 'MD' MEMORY DISPLAY  
00398A F9C5 00 A FCB \$00 NOT USED  
00399A F9C6 00 A FCB \$00 NOT USED  
00400A F9C7 0F A FCB \$0F 'F'  
00401A F9C8 02 A FCB \$02 '2'  
00402A F9C9 05 A FCB \$05 '5'  
00403A F9CA 08 A FCB \$08 '8'  
00404A F9CB 15 A FCB \$15 'FC' FUNCTION CLEAR  
00405A F9CC 11 A FCB \$11 'EX' ESCAPE  
00406A F9CD 00 A FCB \$00 NOT USED  
00407A F9CE 00 A FCB \$00 NOT USED  
00408A F9CF 0E A FCB \$0E 'E'  
00409A F9D0 03 A FCB \$03 '3'  
00410A F9D1 06 A FCB \$06 '6'  
00411A F9D2 09 A FCB \$09 '9'  
00412A F9D3 16 A FCB \$16 'P/L' PUNCH/LOAD  
00413A F9D4 12 A FCB \$12 'RD' REGISTER DISPLAY  
00414A F9D5 00 A FCB \$00 NOT USED  
00415A F9D6 00 A FCB \$00 NOT USED  
00416A F9D7 0D A FCB \$0D 'D'  
00417A F9D8 0C A FCB \$0C 'C'  
00418A F9D9 0B A FCB \$0B 'B'  
00419A F9DA 0A A FCB \$0A 'A'  
00420A F9DB 17 A FCB \$17 'T/B' TRACE/BREAKPOINT  
00421A F9DC 13 A FCB \$13 'GO' GO TO USER PROG

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00423 ****
00424 *
00425 * REGISTER DISPLAY ROUTINE
00426 *
00427 ****
00428A F9DD 7D 8132 A REGDIS TST INIT FIRST PASS ?
00429A F9E0 26 08 F9EA BNE REGLOP NO; BYPASS INITIALIZATION
00430A F9E2 7C 8132 A INC INIT
00431A F9E5 7F 8116 A CLR REGNUM START WITH 'PC' DISPLAY
00432A F9E8 20 78 FA62 BRA REGAD1 GO TO FIRST PASS ENTRY POINT
00433A F9EA B6 812E A REGLOP LDAA ROWCOL SEE IF ANY KEY DOWN
00434A F9ED 81 15 A CMPA #$15 WAS IT 'E' KEY ?
00435A F9EF 26 05 F9F6 BNE ARN1M NO, FIND WHICH KEY IT IS
00436A F9F1 8D 58 FA4B BSR REGADV YES, STOP ANY PENDING OPERATION
00437A F9F3 7E F857 A JMP PROMPT ESCAPE TO PROMPT ROUTINE
00438A F9F6 BD FB22 A ARN1M JSR KEYTST EXITS IF 'E' OR NO KEY
00439A F9F9 2B 18 FA13 BMI NUMKEY N CODE SET IF IT WAS A HEX KEY
00440A F9FB 81 02 A CMPA #2 IF NOT HEX, CHECK FOR 'RD' KEY
00441A F9FD 27 4C FA4B BEQ REGADV BRANCH TO ADVANCE REGISTER
00442A F9FF 81 03 A CMPA #3 CHECK FOR GO KEY
00443A FA01 26 07 FA0A BNE TRAC IF NOT "GO", CHECK TRACE COMMAND
00444A FA03 86 80 A LDAA #$80
00445A FA05 B7 812F A STAA NFLAG MAKE NFLAG NEG
00446A FA08 20 04 FA0E BRA TRAC1 THIS MEANS CONTINUE FROM A BRKPT
00447A FA0A 81 07 A TRAC CMPA #7 WAS IT "T" KEY?
00448A FA0C 26 08 FA16 BNE DUNPAS NO, EXIT THIS PASS
00449A FA0E 8D 3B FA4B TRAC1 BSR REGADV YES, COMPLETE PRESENT OPERATION
00450A FA10 7E FCD5 A JMP TRACE & GO TO TRACE PROGRAM
00451A FA13 BD FB44 A NUMKEY JSR ROLENT KEY IS HEX, SO SHIFT INTO HEXBUF
00452A FA16 7D 8116 A DUNPAS TST REGNUM KEY PROCESSED SO UPDATE & EXIT
00453A FA19 26 08 FA23 BNE PAST1
00454A FA1B FE 8118 A LDX HEXBUF 'PC' MODE SO:
00455A FA1E A6 00 A LDAA 0,X GET OP-CODE,
00456A FA20 B7 811A A STAA HEXBUF+2 STORE TO HEXBUF
00457A FA23 BD FC0B A PAST1 JSR DYSCOD CONVERT HEXBUF TO 7-SEGMENT
00458A FA26 B6 8116 A LDAA REGNUM
00459A FA29 26 07 FA32 BNE PAST2 IF NOT "PC" CHECK FOR ANOTHER KEY
00460A FA2B CE 7339 A LDX #$7339 7-SEGMENT CODE FOR "PC"
00461A FA2E FF 8122 A STX DISBUF+6 PUT IN DIGITS 7 & 8
00462A FA31 39 RTS ***RETURN***
00463A FA32 81 05 A PAST2 CMPA #5 CHECK FOR "SP"
00464A FA34 26 06 FA3C BNE BLANK IF NOT, GO TO BLANKING ROUTINE
00465A FA36 CE 6D73 A LDX #$6D73 7-SEGMENT CODE FOR "SP"
00466A FA39 FF 8122 A STX DISBUF+6 PUT IN DIGITS 7 & 8
00467A FA3C 84 03 A BLANK ANDA #$03 A-REG CONTAINS REGNUM
00468A FA3E 4A DECA
00469A FA3F 26 04 FA45 BNE CLR14 IF A-REG NOT 0, BLANK FIRST 4
00470A FA41 86 30 A LDAA *%00110000 CLEAR DIGITS 5 & 6
00471A FA43 20 02 FA47 BRA CLR1 OK YOU'RE DONE SO RETURN
00472A FA45 86 0F A CLR14 LDAA *%00001111 BLANK FIRST FOUR DISPLAYS
00473A FA47 BD F848 A CLR1 JSR CLRDSP GO CLEAR DISPLAY
00474A FA4A 39 RTS ***RETURN***

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00477A	FA4B	FE	8118	A	REGADV	LDX	HEXBUF	DONE HERE TO SAVE CODE
00478A	FA4E	B6	811A	A		LDAA	HEXBUF+2	A-REG OR X-REG WILL BE NEEDED
00479A	FA51	F6	8116	A		LDAB	REGNUM	GET CURRENT REGISTER NUMBER
00480A	FA54	5C				INC8		ADV TO NEXT REGISTER
00481A	FA55	F7	8116	A		STAB	REGNUM	UPDATE REGISTER NUMBER
00482A	FA58	C1	06	A		CMPB	#6	CHECK FOR OVERRUN
00483A	FA5A	26	0E	FABA		BNE	ADV1	NOT WRAP AROUND (SO NOT 'PC')
00484A	FA5C	7F	8116	A		CLR	REGNUM	LAST REG WAS "SP" SO RESET TO "PC"
00485A	FA5F	FF	812B	A		STX	USP	UPDATED SP WAS IN X-REG; SAVE IT
00486A	FA62	FE	8129	A	REGAD1	LDX	UPC	GET STORED USER PROG COUNTER
00487A	FA65	FF	8118	A		STX	HEXBUF	PUT IN WORKING/DISPLAY BUFFER
00488A	FA68	20	55	FABF		BRA	OUT2	EXIT BY WAY OF 2-BYTE OPTION
00489A	FA6A	5A			ADV1	DEC8	REGNUM	REGNUM WILL BE DEC'D TO 0
00490A	FA6B	26	10	FA7D		BNE	ADV2	WASN'T 'ID' SO KEEP LOOKING
00491A	FA6D	FF	8129	A		STX	UPC	X-REG HAD UPDATED USER PC
00492A	FA70	FE	8127	A		LDX	UX	GET STORED USER X-REG VALUE
00493A	FA73	FF	8118	A		STX	HEXBUF	PUT IN DISPLAY/CHANGE BUFFER
00494A	FA76	86	1D	A		LDA8	#\$1D	7-SEG CODE FOR "ID"
00495A	FA78	B7	811B	A		STAA	HEXBUF+3	DYSCOD CONVERTS TO 7-SEGMENT
00496A	FA7B	20	42	FABF		BRA	OUT2	EXIT WITH 2-BYTE OPTION
00497A	FA7D	5A			ADV2	DEC8		
00498A	FA7E	26	16	FA96		BNE	ADV3	IF NOT 'AA' MODE GO ON
00499A	FA80	FF	8127	A		STX	UX	UPDATE USER X-REG
00500A	FA83	B6	8126	A		LDA8	UA	GET USER'S A-REG
00501A	FA86	B7	811A	A		STAA	HEXBUF+2	PUT IN LOCATIONS 5&6
00502A	FA89	86	AA	A		LDA8	#\$AA	CODE FOR 7TH/8TH DIGITS
00503A	FA8B	B7	811B	A	SOUT1	STAA	HEXBUF+3	
00504A	FA8E	B7	8135	A	OUT1	STAA	FLG24	SET TO 2 NIBBLE MODE
00505A	FA91	7F	8134	A	DUNADV	CLR	ROLFLG	SET FIRST PASS FLAG FOR ROLENT
00506A	FA94	20	80	FA16		BRA	DUNPAS	GO UPDATE THE DISPLAY
00507A	FA96	5A			ADV3	DEC8		
00508A	FA97	26	0D	FAA6		BNE	ADV4	IF NOT 'BB' GO AROUND
00509A	FA99	B7	8126	A		STAA	UA	UPDATE USER'S A-REG
00510A	FA9C	B6	8125	A		LDA8	UB	GET HIS B-REG
00511A	FA9F	B7	811A	A		STAA	HEXBUF+2	PREPARE TO DISPLAY/CHANGE IT
00512A	FAA2	86	AB	A		LDA8	#\$AB	CODE FOR DIGITS 7 & 8
00513A	FAA4	20	E5	FA8B		BRA	SOUT1	STORE CODE-EXIT VIA 1-BYTE OPT
00514A	FAA6	5A			ADV4	DEC8		
00515A	FAA7	26	0D	FAB6		BNE	ADV5	
00516A	FAA9	B7	8125	A		STAA	UB	UPDATE
00517A	FAAC	B6	8124	A		LDA8	UCC	GET USER'S COND CODE REG
00518A	FAAF	B7	811A	A		STAA	HEXBUF+2	
00519A	FAB2	86	CC	A		LDA8	#\$CC	
00520A	FAB4	20	D5	FA8B		BRA	SOUT1	
00521A	FAB6	B7	8124	A	ADV5	STAA	UCC	BY DEFAULT MUST BE SP MODE
00522A	FAB9	FE	812B	A		LDX	USP	
00523A	FABC	FF	8118	A		STX	HEXBUF	PREPARE SP FOR DISP/CHNG
00524A	FABF	7F	8135	A	OUT2	CLR	FLG24	SET TO 4 NIBBLE MODE
00525A	FAC2	20	CD	FA91		BRA	DUNADV	

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00527      *
00528      * TEST FOR HEX/FUNCTION KEY AND PUT KEY VALUE IN A
00529      *
00530A FAC4 78 812E A GETIT  ASL     ROWCOL
00531A FAC7 0D          SEC
00532A FAC8 76 812E A ROR     ROWCOL  SET BIT 7 TO ACKNOWLEDGE KEY
00533A FACB B6 8117 A LDAA    KEY    NOW GET THE DECODED KEY
00534A FACE 81 10  A CMPA    #$10   CHECK FOR HEX */FUNCTION KEY
00535A FAD0 2B 09 FADB BMI    RET    IF N CODE SET KEY WAS HEX
00536A FAD2 81 11  A CMPA    #$11   CHECK FOR ESCAPE KEY
00537A FAD4 26 03 FAD9 BNE    ARN1   IF NOT GO AROUND
00538A FAD6 7E F857 A JMP    PROMPT EXIT TO PROMPT SEQUENCE
00539A FAD9 84 0F A ARN1  ANDA    #$0F   CONDENSE FUNCTION * TO 0 - 7
00540A FADB 39          RET    RTS    ** RETURN **
00541      * N CONDITION CODE INDICATES KEY TYPE

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00543      ****
00544      *
00545      * MEMORY CHANGE ROUTINE
00546      *
00547      ****
00548A FADC 7D 8137 A MEMCH  TST    INIT2
00549A FADF 26 51 FB32 BNE    OFFSET
00550A FAE1 FE 8118 A LDX    HEXBUF  POINT AT MEM LOC SPECIFIED
00551A FAE4 FF 8111 A STX    XTMP3
00552A FAE7 7D 8132 A TST    INIT   SEE IF FIRST PASS
00553A FAEA 26 08 FAF4 BNE    BEGIN  IF NOT BYPASS INITIALIZATION
00554A FAEC 7C 8132 A INC    INIT   INDICATE NOT FIRST PASS
00555A FAEF 7C 8135 A INC    FLG24 SET TO 2-NIBBLE MODE
00556A FAF2 20 1B FB0F BRA    FUNDIS SET UP DISPLAY
00557A FAF4 8D 2C FB22 BEGIN  BSR    KEYTST GO SEE IF KEY PENDING
00558A FAF6 2A 09 FB01 BPL    FUNKEY IF FUNCTION KEY SEE WHICH ONE
00559A FAF8 8D 4A FB44 BSR    ROLEN  IF * KEY UPDATE HEXBUF
00560A FAFA B6 811A A LDAA   HEXBUF+2 GET VALUE ENTERED
00561A FAFD A7 00  A STAA   0,X    STORE (OR AT LEAST TRY TO)
00562A FAFF 20 19 FB1A BRA    DISP   LEAVE VIA DISPLAY
00563A FB01 26 03 FB06 FUNKEY BNE    OFF    M KEY MEANS BACK UP 1 LOCATION.
00564A FB03 09          DEX
00565A FB04 20 09 FB0F BRA    FUNDIS
00566A FB06 81 04  A OFF   CMPA   #4
00567A FB08 27 28 FB32 BEQ    OFFSET
00568A FB0A 81 03  A GOKEY CMPA   #3   SEE IF G KEY
00569A FB0C 26 0C FB1A BNE    DISP   IF NOT EXIT
00570A FB0E 08          INX
00571A FB0F FF 8118 A FUNDIS STX    HEXBUF  G KEY MEANS ADVANCE TO NEXT LOC
00572A FB12 A6 00  A LDAA   0,X    GET NEW ADDR INTO HEXBUF
00573A FB14 B7 811A A STAA   HEXBUF+2 GET DATA FROM NEW LOC
00574A FB17 7F 8134 A CLR    ROLFLG INITIAL VAL TO DISPLAY
00575A FB1A A6 00  A DISP   LDAA   0,X    SET ROLFLG FIRST PASS FLAG
00576A FB1C B7 811B A STAA   HEXBUF+3 GET ACTUAL VALUE AT LOC
00577A FB1F 7E FC08 A JMP    DYS   STORE TO DIGITS 7 & 8

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00579 \*  
 00580 \* GET KEY VALUE AND RETURN  
 00581 \*  
 00582A FB22 7D 8130 A KEYTST TST EXFLAG EXPANSION ROM PRESENT?  
 00583A FB25 2F 03 FB2A BLE SKIP1 NO, CONTINUE NORMAL OPERATION.  
 00584A FB27 7E F008 A JMP EXGET EXGET-RETURN TO CALLING PROGRAM.  
 00585A FB2A 7D 812E A SKIP1 TST ROHCOL CHECK FOR NEW KEY  
 00586A FB2D 2A 95 FAC4 BPL GETIT IF KEY; GO GET IT  
 00587A FB2F 32 PULA  
 00588A FB30 32 PULA ADJUST STACK TO RETURN TO "PUT"  
 00589A FB31 39 RTS \*\*RETURN\*\*  
 00590 \* TO ROUTINE THAT CALLED ROUTINE THAT CALLED KEYTST!!!

00592 \*  
 00593 \* OFFSET ROUTINE  
 00594 \*  
 00595A FB32 7D 8137 A OFFSET TST INIT2 FIRST TIME THRU?  
 00596A FB35 26 77 FBAE BNE OFST NO!  
 00597A FB37 7C 8137 A INC INIT2 NO MORE OF THIS  
 00598A FB3A 7F 8134 A CLR ROLFLG PREPARE TO DISPLAY HEX CHARACTERS  
 00599A FB3D 7F 8135 A CLR FLG24  
 00600A FB40 86 7F A LDAA #\$01111111  
 00601A FB42 20 75 FBB9 BRA DISP1

00603 \*  
 00604 \* HEX DIGIT HANDLING ROUTINE  
 00605 \*  
 00606A FB44 7D 8134 A ROLENT TST ROLFLG CHECK FOR FIRST PASS  
 00607A FB47 26 0D FB56 BNE ROLL IF 0; FIRST PASS  
 00608A FB49 7C 8134 A INC ROLFLG KNOCK DOWN FIRST PASS FLAG  
 00609A FB4C 7D 8135 A TST FLG24 TEST NIBBLE MODE = 2 OR 4  
 00610A FB4F 26 12 FB63 BNE BOT2 IF SET, IN 2 NIBBLE MODE  
 00611A FB51 7F 8118 A CLR HEXBUF 4 NIBBLE MODE  
 00612A FB54 20 1F FB75 BRA BOT4  
 00613A FB56 7D 8135 A ROLL TST FLG24 CHECK MODE  
 00614A FB59 27 0C FB67 BEQ DUBROL IF ZERO; GO DO 2-BYTE ROLL  
 00615A FB5B F6 811A A LDAB HEXBUF+2 GET CURRENT DISPLAY VALUE  
 00616A FB5E 58 ASLB MOVE LEFT 4 BIT POSITIONS  
 00617A FB5F 58 ASLB  
 00618A FB60 58 ASLB  
 00619A FB61 58 ASLB  
 00620A FB62 1B ABA ADD NEW NIBBLE (FROM A-REG)  
 00621A FB63 B7 811A A BOT2 STAA HEXBUF+2 UPDATE DISPLAY VALUE  
 00622A FB66 39 RTS  
 00623A FB67 C6 04 A DUBROL LDAB #4 PREPARE LOOP INDEX  
 00624A FB69 78 8119 A LOOPM ASL HEXBUF+1 LEFT SHIFT WITH MSB TO CARRY  
 00625A FB6C 79 8118 A ROL HEXBUF LEFT ROLL WITH CARRY TO LSB  
 00626A FB6F 5A DECB  
 00627A FB70 26 F7 FB69 BNE LOOPM GO TILL INDEX (B) GOES TO 0  
 00628A FB72 BA 8119 A ORAA HEXBUF+1 COMBINE NEW NIBBLE  
 00629A FB75 B7 8119 A BOT4 STAA HEXBUF+1 UPDATE DISPLAYED VALUE  
 00630A FB78 39 RTS \*\*\* RETURN \*\*\*

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00632          *
00633          * KEY FUNCTION DECODING ROUTINE
00634          *
00635A FB79 8D A7 FB22 FNCDCD BSR    KEYTST   GO TEST FOR A KEY
00636A FB7B 2B 0D FB8A      BMI     HEX     KEY DOWN, SEE IF HEX/FUNCTION
00637A FB7D CE FB9E A      LDX     *FNHASH POINT AT LOOK-UP TABLE
00638A FB80 48      HASCLC ASLA    MULX    MULTIPLY FUNCTION # BY 2
00639A FB81 BD F94D A      JSR     ADDXA   ADD TO GET LOOK-UP ADDRESS
00640A FB84 EE 00 A      LDX     0,X     GET HASH TABLE VALUE
00641A FB86 FF 8100 A      STX     MNPTR   SET MAIN POINTER TO NEW ROUTINE
00642A FB89 39      RTS
00643A FB8A 7D 8136 A HEX   TST     FNCFLG  SEE IF IN FSET MODE
00644A FB8D 26 0A FB99      BNE     USERFN  IF SO DO USER'S ROUTINE
00645A FB8F 8D B3 FB44      BSR     ROLEN   SHIFT IN NEW NIBBLE
00646A FB91 8D 78 FC0B      BSR     DYSCOD  CONVERT TO 7-SEG CODES
00647A FB93 86 F0 A DONE   LDAA   *%11110000
00648A FB95 BD F848 A      JSR     CLRDSP
00649A FB98 39      RTS
00650A FB99 FE 8102 A USERFN LDX     UHASH   GET USER FUNCTION TABLE ADDRESS
00651A FB9C 20 E2 FB80      BRA     HASCLC  GO CALC HASH ADDR FOR USER FUNCTIO

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00653          *
00654          * STARTING ADDRESSES OF MAIN ROUTINES
00655          *
00656A FB9E  FADC  A FNHASH FDB    MEMCH
00657A FBA0  F857  A      FDB    PROMPT
00658A FBA2  F9DD  A      FDB    REGDIS
00659A FBA4  FC64  A      FDB    GO
00660A FBA6  FC4C  A      FDB    FSET
00661A FBA8  FC59  A      FDB    FCLR
00662A FBAA  FE1C  A      FDB    PLOAD
00663A FBAC  FC00  A      FDB    TBRK

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00665      *
00666      * SUBROUTINE TO CALCULATE OFFSET
00667      *
00668A FBAE BD FB22 A OFST JSR KEYTST OBTAIN A KEY
00669A FBB1 2A 0F FBC2 BPL FNC IS IT NOT HEX?
00670A FBB3 8D 8F FB44 BSR ROLENT ROLL IN THE HEX CHARACTER
00671A FBB5 8D 54 FC0B DSP BSR DYSCOD ADDR IS DISPLAYED HERE
00672A FBB7 86 70 A LDAA #X01110000
00673A FBB9 BD F848 A DISP1 JSR CLRDSP
00674A FBBC 86 77 A LDAA #$77 DISPLAY AN "A" FOR ADDRESS
00675A FBBE B7 8123 A STAA DISBUF+7 PUT IT ON THE DISPLAY
00676A FBC1 39 RTS **RETURN**
00677A FBC2 81 03 A FNC CMPA #3 A GO KEY?
00678A FBC4 26 44 FC0A BNE ENDOFF TRY AGAIN
00679A FBC6 FE 8111 A LDX XTMP3 GET ADDR TO OFFSET FROM(USER PC)
00680A FBC9 08 INX ADJUST OFFSET TO ADDR. AFTER
00681A FBCA FF 8111 A STX XTMP3 SAVE IT FOR CALCULATIONS
00682A FBCD 09 DEX RESTORE TO CORRECT ADDR.
00683A FBCE F6 8119 A LDAB HEXBUF+1 LOAD ADDR FROM DISPLAY
00684A FBD1 F0 8112 A SUBB XTMP3+1 SUBTRACT USER PC
00685A FBD4 B6 8118 A LDAA HEXBUF
00686A FBD7 B2 8111 A SBCA XTMP3
00687A FBDA 29 13 FBEF BVS BADOFS OFFSET TOO LARGE
00688A FBDC 27 07 FBES BEQ GOODOF JUST RIGHT!
00689A FBDE 43 COMA
00690A FBDF 26 0E FBEF BNE BADOFS GOOD TRY ANY WAY
00691A FBE1 C1 80 A CMPB #$80 MAKE SURE OFFSET WITHIN LIMITS
00692A FBE3 20 01 FBEG BRA GOOD
00693A FBE5 5D GOODOF TSTB
00694A FBES 2B 07 FBEF GOOD BMI BADOFS
00695A FBE8 E7 00 A STAB 0,X
00696A FBEA F7 811A A STAB HEXBUF+2
00697A FBED 20 05 FBF4 BRA PAST
00698A FBEF C6 FF A BADOFS LDAB #$FF
00699A FBF1 F7 811A A STAB HEXBUF+2
00700A FBF4 FF 8118 A PAST STX HEXBUF
00701A FBF7 FF 8111 A STX XTMP3 RESTORE USER PROGRAM COUNTER
00702A FBFA E6 00 A LDAB 0,X GET OLD/CHANGED BYTE
00703A FBFC F7 811B A STAB HEXBUF+3 DISPLAY IT
00704A FBFF 7F 8134 A CLR ROLFLG
00705A FC02 7C 8135 A INC FLG24 RETURN FLAG TO ORIGINAL STATE
00706A FC05 7F 8137 A CLR INITZ
00707A FC08 8D 01 FC0B DYS BSR DYSCOD
00708A FC0A 39 ENDOFF RTS **RETURN**

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00710	*				
00711		* DECODE HEX INTO 7-SEGMENT CODES			
00712	*				
00713A FC0B 36	DYSCOD PSHA		SAVE A-REG		
00714A FC0C CE 8118 A	LDX #HEXBUF		POINT AT HEX BUFFER		
00715A FC0F A6 00 A LP01	LDAA 0,X		GET HEX BYTE		
00716A FC11 16	TAB		MAKE AN EXTRA COPY OF IT		
00717A FC12 54	LSRB				
00718A FC13 54	LSRB		RIGHT JUSTIFY HIGH NIBBLE		
00719A FC14 54	LSRB				
00720A FC15 54	LSRB		HIGH NIBBLE IN B-REG		
00721A FC16 84 0F A	ANDA #\$0F		LOW NIBBLE IN A-REG		
00722A FC18 37	PSHB		SAVE ON STACK		
00723A FC19 36	PSHA				
00724A FC1A 08	INX		POINT AT NEXT BYTE		
00725A FC1B BC 811C A	CPX #HEXBUF+4				
00726A FC1E 26 EF FC0F	BNE LP01		LOOP TILL 4 BYTES CONVERTED		
00727A FC20 CE 8123 A	LDX #DISBUF+7		POINT AT DISPLAY BUFFER		
00728A FC23 C6 07 A	LDAB #7		INITIALIZE LOOP INDEX		
00729A FC25 FF 810F A LP02	STX XTMP2		SAVE FOR NOW		
00730A FC28 CE FC3C A	LDX #DYSTBL		POINT AT LOOK UP TABLE		
00731A FC2B 32	PULA				
00732A FC2C BD F94D A	JSR ADDXA		ADD TO GET LOOK-UP ADDRESS		
00733A FC2F A6 00 A	LDAA 0,X		GET SEVEN-SEGMENT CODE		
00734A FC31 FE 810F A	LDX XTMP2		RECOVER DYSBUF POINTER		
00735A FC34 A7 00 A	STAA 0,X		STORE CODE TO DYSBUF		
00736A FC36 09	DEX		POINT TO NEXT DYSBUF POSITION		
00737A FC37 5A	DEC B		DECREMENT LOOP INDEX		
00738A FC38 2A EB FC25	BPL LP02		LOOP TILL ALL DYSBUF CODED		
00739A FC3A 32	PULA		RESTORE A-REG		
00740A FC3B 39	RTS		*** RETURN ***		

00742	*				
00743		* 7-SEGMENT LOOK-UP TABLE			
00744	*				
00745A FC3C 3F A	DYSTBL FCB \$3F	'0'			
00746A FC3D 06 A	FCB \$06	'1'			
00747A FC3E 5B A	FCB \$5B	'2'			
00748A FC3F 4F A	FCB \$4F	'3'			
00749A FC40 66 A	FCB \$66	'4'			
00750A FC41 6D A	FCB \$6D	'5'			
00751A FC42 7D A	FCB \$7D	'6'			
00752A FC43 07 A	FCB \$07	'7'			
00753A FC44 7F A	FCB \$7F	'8'			
00754A FC45 67 A	FCB \$67	'9'			
00755A FC46 77 A	FCB \$77	'A'			
00756A FC47 7C A	FCB \$7C	'B'			
00757A FC48 39 A	FCB \$39	'C'			
00758A FC49 5E A	FCB \$5E	'D'			
00759A FC4A 79 A	FCB \$79	'E'			
00760A FC4B 71 A	FCB \$71	'F'			

00763                   \*  
00764                   \* SPECIAL FUNCTION SET  
00765                   \*  
00766A FC4C CE 716D A FSET   LDX    \*\$716D 7-SEG CODE FOR 'FS'  
00767A FC4F FF 8122 A         STX    DISBUF+6 PUT IT IN 7TH & 8TH DIGITS  
00768A FC52 86 01 A         LDAA    #1  
00769A FC54 B7 8136 A         STAA    FNCFLG SET FUNCTION FLAG  
00770A FC57 20 08 FC61      BRA    ALDUN EXIT

00772                   \*  
00773                   \* SPECIAL FUNCTION CLEAR  
00774                   \*  
00775A FC59 86 C0 A FCLR   LDAA    #\$11000000  
00776A FC5B BD F848 A         JSR    CLRDSP  
00777A FC5E 7F 8136 A         CLR    FNCFLG CLEAR FUNCTION FLAG  
00778A FC61 7E F871 A ALDUN JMP    PROMP1 \*\* EXIT (SEE NOTE)\*\*\*  
00779                   \* EXITS TO PROMPT AFTER FLAG INITIALIZATION  
00780                   \* SO AS NOT TO DISTURB ANY OPERATION IN PROGRESS  
00781                   \* --RESULTS IN FUNCTION DECODE ADDRESS BEING PUT AT  
00782                   \* MNPTR SO THAT FUNCTION TAKES CONTROL

00784	*****					
00785	*					
00786	* GO TO ROUTINE					
00787	*					
00788	*****					
00789A	FC64 BD F839	A	GO	JSR	EFPI	ENABLE FRONT PANEL NMI
00790A	FC67 0D			SEC		
00791A	FC68 76 8130	A		ROR	EXFLAG	MAKE EXFLAG NEGATIVE
00792A	FC6B 7D 8134	A		TST	ROLFLG	WAS NUMERIC DATA INPUT BEFORE "G"?
00793A	FC6E 27 06 FC76			BEQ	FTST	NO, BYPASS UPC INITIALIZATION
00794A	FC70 FE 8118	A		LDX	HEXBUF	YES, GET USER PROG COUNTER
00795A	FC73 FF 8129	A		STX	UPC	INITIALIZE USER PROG COUNTER
00796A	FC76 7D 8136	A	FTST	TST	FNCFLG	TEST FOR FUNCTION SET MODE
00797A	FC79 27 0C FC87			BEQ	NORMGO	CLEAR, GO TO NORMAL GO ENTRY
00798A	FC7B FE 8129	A		LDX	UPC	GET ADDRESS OF USER MAIN PROG
00799A	FC7E FF 8100	A		STX	MNPTR	INSTALL IT IN "MAIN" POINTER
00800A	FC81 CE F90B	A		LDX	*PUT	
00801A	FC84 FF 8129	A		STX	UPC	MAKE ROUTINE JUMP TO "PUT" AFTER SP
00802A	FC87 BD FDE1	A	NORMGO	JSR	INBKPT	INSTALL BREAKPOINTS
00803A	FC8A BE 812B	A	GOTO	LDS	USP	LOAD USER'S STACK POINTER
00804A	FC8D 86 55	A		LDAA	*\$55	BEGIN TEST FOR EXISTENCE OF STACK
00805A	FC8F 36			PSHA		TRY TO PUT ON USER'S STACK
00806A	FC90 32			PULA		IF HIS SP WAS OK A-REG=\$55
00807A	FC91 81 55	A		CMPA	*\$55	SEE IF IT IS
00808A	FC93 26 10 FC45			BNE	BADSTK	IF NOT, GO CANNOT CONTINUE
00809A	FC95 B6 812A	A		LDAA	UPC+1	GET LOW BYTE OF USER "PC"
00810A	FC98 36			PSHA		STACK IT TO PREPARE FOR RTS
00811A	FC99 B6 8129	A		LDAA	UPC	HIGH BYTE
00812A	FC9C 36			PSHA		STACK IT
00813A	FC9D 86 AA	A		LDAA	*\$AA	TEST PATTERN FOR STACK TEST
00814A	FC9F 36			PSHA		
00815A	FCA0 32			PULA		IF OK IT WILL BE \$AA
00816A	FCA1 81 AA	A		CMPA	*\$AA	SEE IF IT IS
00817A	FCA3 27 11 FCB6			BEQ	GOEXIT	YES, CONTINUE TO LOAD USER REGS
00818A	FCA5 BD F846	A	BADSTK	JSR	CLRD	CLEAR DISPLAY
00819A	FCA8 CE 6D73	A		LDX	*\$6D73	7-SEG FOR 'SP'
00820A	FCAB FF 811E	A		STX	DISBUF+2	
00821A	FCAE 86 53	A		LDAA	*\$53	7-SEG FOR '?’
00822A	FCB0 B7 8123	A		STAA	DISBUF+7	
00823A	FCB3 7E F861	A		JMP	PROMPG	ENTER PROMPT SEQ AFTER DISBUF INIT
00824A	FCB6 FE 8127	A	GOEXIT	LDX	UX	LOAD USER X-REG
00825A	FCB9 F6 8125	A		LDAB	UB	LOAD USER B-REG
00826A	FCBC B6 8126	A		LDAA	UA	GET USER A-REG
00827A	FCBF 36			PSHA		SAVE ON STACK (USER'S STACK)
00828A	FCC0 7D 812F	A		TST	NFLAG	
00829A	FCC3 27 05 FCCA			BEQ	ARN17	IF NOT TRACE MODE BYPASS TIMER INIT
00830A	FCC5 86 B2	A		LDAA	*\$B2	SET-UP TIMER FOR TRACE TRIGGER
00831A	FCC7 B7 8085	A		STAA	TCNTRL	
00832A	FCCA B6 8124	A	ARN17	LDAA	UCC	PREPARE TO INITIALIZE USER COND. C
00833A	FCCD 06			TAP		GET THEM INTO CC-REG
00834A	FCCE 32			PULA		LOAD USER A-REG WITHOUT AFFECTING
00835A	FCCF 39			RTS		***EXIT TO USER PROG***

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00837 ****
00838 *
00839 *      BREAK POINT SUBROUTINE
00840 *
00841 ****
00842A FCDD 7D 8136 A TBRK   TST    FNCFLG
00843A FCD3 26 05 FCDA     BNE    CONT
00844A FCD5 7C 812F A TRACE  INC    NFLAG
00845A FCD8 20 B0 FC8A     BRA    GOTO
00846A FCDA 7D 812D A CONT  TST    INIT1
00847A FCDD 26 17 FCF6     BNE    ACTION  1ST TIME THRU?
00848A FCDF 7F 8134 A     CLR    ROLFLG
00849A FCE2 7C 812D A     INC    INIT1  DON'T WANT TO DO THIS AGAIN
00850A FCE5 7F 8142 A     CLR    NUMBER NO BKPTS.
00851A FCE8 CE 8143 A     LDX    *BOF   GET TABLE ADDR. OF 1ST BPT.
00852A FCEB FF 813E A     STX    POINTR SET UP TABLE POINTER
00853A FCEE FF 8140 A     STX    TOFT   INITIALIZE TOP OF TABLE POINTER
00854A FCF1 7F 811B A     CLR    HEXBUF+3 SHOW WHICH BPT IS DISPLAYED
00855A FCF4 20 7D FD73     BRA   DISPLAY DO THE ACTUAL LED DISPLAY
00856A FCF6 7D 8137 A ACTION TST    INIT2
00857A FCF9 26 0E FD09     BNE   ACTON2
00858A FCFB 7C 8137 A     INC    INIT2
00859A FCFE FE 8143 A     LDX    BOF
00860A FD01 F6 8142 A     LDAB   NUMBER
00861A FD04 F7 811B A     STAB   HEXBUF+3
00862A FD07 20 73 FD7C     BRA   DISPLAY1
00863A FD09 BD FB22 A ACTON2 JSR    KEYTST WHICH KEY WAS PRESSED
00864A FD0C 2A 08 FD16     BPL   FUNCTN DECODE A FUNCTION KEY
00865A FD0E 7F 8135 A     CLR    FLG24  HANDLE HEX KEYS-SET UP DISPLAY
00866A FD11 BD FB44 A     JSR    ROLENT ROLL HEX NIBBLE INTO HEXBUF
00867A FD14 20 69 FD7F     BRA   DISPLAY GO DISPLAY IT
00868A FD16 FE 813E A FUNCTN LDX   POINTR SET INDEX TO TABLE POINTER
00869A FD19 81 03 A     CMPA   *$3
00870A FD1B 26 24 FD41     BNE   FSET33 TRY ADDING NEW BKPT.
00871A FD1D 8C 8143 A     CPX    *BOF
00872A FD20 26 05 FD27     BNE   SKIP2 NOT THE BOTTOM OF TABLE
00873A FD22 BC 8140 A     CPX    TOFT  IS IT ALSO THE TOP OF TABLE
00874A FD25 27 0A FD31     BEQ   SKIP  DON'T MESS WITH IT
00875A FD27 08           SKIP2 INX
00876A FD28 08           INX
00877A FD29 BC 8140 A     CPX    TOFT SEEK TOP OF TABLE
00878A FD2C 26 03 FD31     BNE   SKIP
00879A FD2E CE 8143 A     LDX    *BOF YES WRAP AROUND
00880A FD31 FF 813E A SKIP  STX    POINTR UPDATE TABLE POINTR
00881A FD34 EE 00 A       LDX    0,X  LOA BPT. ADDR.
00882A FD36 FF 8118 A     STX    HEXBUF PUT IN DISPLAY
00883A FD39 B6 8142 A     LDAA   NUMBER LOAD #OF BKPTS.
00884A FD3C B7 811B A     STAA   HEXBUF+3
00885A FD3F 20 3E FD7F     BRA   DISPLAY DISPLAY IT

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00887A	FD41	81 04	A	FSET33	CMPA	*4	ADD NEW BPT.
00888A	FD43	26 68	FDAD		BNE	FCLR33	NO MAYBE REMOVE ONE
00889A	FD45	B6 8142	A		LDAA	NUMBER	
00890A	FD48	81 08	A		CMPA	*8	NO MORE ROOM?
00891A	FD4A	2C 3B	FD87		BGE	ENDBPT	YES GET OUT
00882A	FD4C	7F 8134	A		CLR	ROLFLG	
00893A	FD4F	8D 37	FD88		BSR	FNDBRK	
00894A	FD51	27 34	FD87		BEQ	ENDBPT	DON'T ADD THE SAME BREAKPOINT
00895A	FD53	FE 8140	A		LDX	TOFT	
00896A	FD56	B6 8118	A		LDAA	HEXBUF	
00897A	FD59	A7 00	A		STAA	0,X	
00898A	FD5B	B6 8119	A		LDAA	HEXBUF+1	
00899A	FD5E	A7 01	A		STAA	1,X	ADD NEW BKPT.
00900A	FD60	FF 813E	A		STX	POINTR	
00901A	FD63	08			INX		
00902A	FD64	08			INX		ADVANCE INDEX
00903A	FD65	FF 8140	A		STX	TOFT	UPDATE TOP OF TABLE POINTER
00904A	FD68	7C 8142	A		INC	NUMBER	UPDATE # OF BKPTS.
00905A	FD6B	B6 8142	A		LDAA	NUMBER	
00906A	FD6E	B7 811B	A		STAA	HEXBUF+3	DISPLAY UPDATE
00907A	FD71	20 0C	FD7F		BRA	DISPY	
00908A	FD73	7F 8143	A	DISPLAY	CLR	BOF	
00909A	FD76	7F 8144	A		CLR	BOF+1	
00910A	FD79	CE 0000	A		LDX	*0	
00911A	FD7C	FF 8118	A	DISPY1	STX	HEXBUF	
00912A	FD7F	BD FC0B	A	DISPY	JSR	DYSCOD	DISPLAY BKPT
00913A	FD82	86 70	A		LDAA	*X01110000	
00914A	FD84	BD F848	A		JSR	CLRDSP	
00915A	FD87	39			ENDBPT	RTS	***RETURN***
00916A	FD88	CE 8143	A	FNDBRK	LDX	*BOF	
00917A	FD8B	FF 813E	A		STX	POINTR	
00918A	FD8E	B6 8142	A		LDAA	NUMBER	TOP OF TABLE=BEGINNING OF TABLE
00919A	FD91	27 17	FDAA		BEQ	NOTFND	DO NOTHING
00920A	FD93	B6 8118	A		LDAA	HEXBUF	GET BKPT TO REMOVE
00921A	FD96	F6 8119	A		LDAB	HEXBUF+1	BOTH BYTES ARE NEEDED
00922A	FD99	A1 00	A	LOOP1M	CMPA	0,X	SEARCH FOR BPT TO REMOVE
00923A	FD9B	26 04	FDA1		BNE	INCX	NOT FOUND
00924A	FD9D	E1 01	A		CMPB	1,X	CONT. SEARCH
00925A	FD9F	27 0B	FDAC		BEQ	FOUND	FOUND IT!
00926A	FDA1	BC 8140	A	INCX	CPX	TOFT	TOP OF TABLE?
00927A	FDA4	27 04	FDAA		BEQ	NOTFND	
00928A	FDA6	08			INX		
00929A	FDA7	08			INX		
00930A	FDA8	20 EF	FD99		BRA	LOOP1M	
00931A	FDAA	86 01	A	NOTFND	LDAA	#1	
00932A	FDAC	39		FOUND	RTS		***RETURN***

00934A	FDA0	81 05	A	FCLR33	CMPA	*5	CLEAR A BKPT?
00935A	FDAF	26 D6	FD87		BNE	ENDBPT	
00936A	FDB1	8D D5	FD88		BSR	FNDBRK	
00937A	FDB3	26 D2	FD87		BNE	ENDBPT	
00938A	FDB5	7F 8134	A		CLR	ROLFLG	
00939A	FDB8	BC 8140	A	LOOP20	CPX	TOFT	
00940A	FDBB	27 0C	FDC9		BEQ	OUT	
00941A	FDBD	A6 02	A		LDAA	2,X	MOVE TABLE DOWN
00942A	FDBF	A7 00	A		STAA	0,X	
00943A	FDC1	A6 03	A		LDAA	3,X	
00944A	FDC3	A7 01	A		STAA	1,X	
00945A	FDC5	08			INX		
00946A	FDC6	08			INX		MOVE DOWN NEXT BKPT
00947A	FDC7	20 EF	FDB8		BRA	LOOP20	REACH TOP OF TABLE?
00948A	FDC9	FE 8140	A	OUT	LDX	TOFT	
00949A	FDCC	09			DEX		
00950A	FDCC	09			DEX		DEC TO SHOW FEWER BKPTS
00951A	FDCE	FF 8140	A		STX	TOFT	
00952A	FDD1	7A 8142	A		DEC	NUMBER	DISPLAY NEW NUMBER-EXIT
00953A	FDD4	B6 8142	A		LDAA	NUMBER	
00954A	FDD7	B7 811B	A		STAA	HEXBUF+3	
00955A	FDDA	27 97	FD73		BEQ	DISPLY	
00956A	FDDC	FE 8143	A		LDX	BOF	GET FIRST BKPT
00957A	FDDF	20 9B	FD7C		BRA	DISPY1	
00958A	FDE1	CE 8143	A	INBKPT	LDX	*BOF	BEGINNING OF TABLE
00959A	FDE4	CE 3F	A		LDAB	*\$3F	BKPT OPCODE
00960A	FDE6	BC 8140	A	LOOP	CPX	TOFT	
00961A	FDE9	27 30	FE1B		BEQ	END	
00962A	FDEB	FF 813E	A		STX	POINTR	KEEP OLD BKPT ADDR.
00963A	FDEE	EE 00	A		LDX	0,X	READ ACTUAL BKPT ADDR.
00964A	FDF0	AG 00	A		LDAA	0,X	GET OPCODE
00965A	FDF2	E7 00	A		STAB	0,X	PLACE INTERRUPT IN ITS PLACE
00966A	FDF4	FE 813E	A		LDX	POINTR	RESTORE OLD BKPT TABLE ADDR.
00967A	FDF7	A7 10	A		STAA	16,X	SAVE OPCODE ON HASHED TABLE
00968A	FDF9	08			INX		
00969A	F DFA	08			INX		NEXT BKPT
00970A	FDFB	20 E9	FDE6		BRA	LOOP	CONTINUE TILL ALL BKPTS INSERTED
00971A	FDFD	CE 8143	A	RMBKPT	LDX	*BOF	BEGINNING OF BKPT TABLE
00972A	FE00	BC 8140	A	LOOP40	CPX	TOFT	
00973A	FE03	27 16	FE1B		BEQ	END	
00974A	FE05	FF 813E	A		STX	POINTR	USE POINTR AS TEMP STORAGE
00975A	FE08	E6 10	A		LDAB	16,X	RECOVER OPCODE
00976A	FE0A	EE 00	A		LDX	0,X	RETRIEVE OPCODE'S ADDR.
00977A	FE0C	A6 00	A		LDAA	0,X	CHECK FOR BKPT
00978A	FE0E	81 3F	A		CMFA	*\$3F	
00979A	FE10	26 02	FE14		BNE	WHOOPS	ITS CHANGED DON'T CHANGE AGAIN
00980	*						THIS ALLOWS USER TO CHANGE BREAKPOINTS IF HE WISHE
00981A	FE12	E7 00	A		STAB	0,X	REPLACE OPCODE
00982A	FE14	FE 813E	A	WHOOPS	LDX	POINTR	GET BACK TABLE ADDR
00983A	FE17	08			INX		
00984A	FE18	08			INX		MOVE ON TO NEXT BKPT
00985A	FE19	20 E5	FE00		BRA	LOOP40	YES FINISH UP
00986A	FE1B	39		END	RTS		***RETURN***

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00988 *
00989 * SET UP PUNCH/LOAD
00990 *
00991A FE1C 7F 8132 A PLOAD CLR VERIFY
00992A FE1F C6 03 A LDAB #3 INITIALIZE ACIA
00993A FE21 F7 800A A STAB ACIA0
00994A FE24 FE 8111 A LDX XTMP3
00995A FE27 7D 8136 A TST FNCFLG
00996A FE2A 26 75 FEA1 BNE LD
00997A FE2C 7D 8137 A PNCH TST INIT2
00998A FE2F 26 10 FE41 BNE INPUT
00999A FE31 7F 8131 A CLR S3FLAG
01000A FE34 7F 8135 A CLR FLG24
01001A FE37 7C 8137 A INC INIT2 LAST TIME THRU
01002A FE3A C6 0B A LDAB #$0B PUT A PROMPT FOR BEG. ADDR.
01003A FE3C CE 813A A LDX #BEGA
01004A FE3F 20 25 FE66 BRA DISP2
01005A FE41 BD FB22 A INPUT JSR KEYTST BEGIN KEYBOARD HANDLER
01006A FE44 2A 05 FE4B BPL GO00 NOT A HEX KEY
01007A FE46 BD FB44 A JSR ROLENT ROLL HEX * IN
01008A FE49 20 28 FE73 BRA DISP11 GO DISPLAY IT
01009A FE4B 8D 32 FE7F G000 BSR FSTCLR DECODE KEY COMMAND
01010A FE4D F6 8118 A LDAB HEXBUF RECOVER INPUTTED ADDR.
01011A FE50 E7 00 A STAB 0,X
01012A FE52 F6 8119 A LDAB HEXBUF+1
01013A FE55 E7 01 A STAB 1,X
01014A FE57 7D 8137 A TST INIT2
01015A FE5A 2B 20 FE7C BMI PUNCH1 GO PUNCH INSTEAD
01016A FE5C C6 80 A LDAB #$80
01017A FE5E F7 8137 A STAB INIT2 KEEP FROM DOING THIS AGAIN
01018A FE61 CE 813C A LDX #ENDA
01019A FE64 C6 0E A LDAB #$0E PUT END ADDR. PROMPT UP
01020A FE66 FF 8111 A DISP2 STX XTMP3
01021A FE69 7F 8134 A CLR ROLFLG
01022A FE6C F7 811B A STAB HEXBUF+3
01023A FE6F 86 7F A LDAA #$01111111
01024A FE71 20 02 FE75 BRA DISP10
01025A FE73 86 70 A DISP11 LDAA #$01110000
01026A FE75 BD FC0B A DISP10 JSR DYSCOD DEPENDS ON DYSCOD NOT CHANGING A
01027A FE78 BD F848 A JSR CLRDSP
01028A FE7B 39 PEND RTS **RETURN**
01029A FE7C 7E FFA7 A PUNCH1 JMP PUNCH
01030A FE7F 26 07 FE88 FSTCLR BNE NXT0 VERIFY?
01031A FE81 7C 8132 A INC VERIFY SET VERIFY MODE FLAG
01032A FE84 32 PULA DO NOT WISH TO RETURN
01033A FE85 32 PULA
01034A FE86 20 38 FEC0 BRA G01 INSTEAD DO A TAPE VERIFY
01035A FE88 81 04 A NXT0 CMPA #4 SET S3FLAG?
01036A FE8A 26 05 FE91 BNE NXT NO
01037A FE8C 7C 8131 A INC S3FLAG GO INTO 300 BAUD MODE
01038A FE8F 20 0D FE9E BRA RET44

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01041A	FE91	81 05	A	NXT	CMPA	\$5	CLEAR S3FLAG?
01042A	FE93	26 05	FE9A		BNE	NXT1	NO
01043A	FE95	7F	8131	A	CLR	S3FLAG	
01044A	FE98	20 04	FE9E		BRA	RET44	
01045A	FE9A	81 03	A	NXT1	CMPA	*\$3	PUNCH/LOAD?
01046A	FE9C	27 02	FEA0		BEQ	ENDFST	YES
01047A	FE9E	32			RET44	PULA	GO BACK TO PUT
01048A	FE9F	32				PULA	
01049A	FEA0	39			ENDFST	RTS	***RETURN***

01051	*						
01052		*	LOAD 1200 BAUD				
01053	*						
01054A	FEA1	BD	F846	A	LD	JSR	CLRD
01055A	FEA4	7D	8133	A		TST	ERROR
01056A	FEAT	26	47	FEF0		BNE	MESAGE
01057A	FEA9	86	4F	A		LDAA	*\$4F      INITIALIZE DISPLAY
01058A	FEAB	B7	811F	A		STAA	DISBUF+3
01059A	FEAE	CE	065B	A		LDX	*\$065B
01060A	FEB1	FF	811C	A	KEYM	STX	DISBUF
01061A	FEB4	86	53	A		LDAA	*\$53
01062A	FEB6	B7	8123	A		STAA	DISBUF+7
01063A	FEB9	BD	F822	A		JSR	KEYTST    START KEY HANDLER
01064A	FEBC	2B	30	FEFF		BMI	QUIT
01065A	FEDE	8D	BF	FE7F		BSR	FSTCLR
01066A	FEC0	7F	8133	A	G01	CLR	ERROR
01067A	FEC3	B7	8138	A		STAA	LDFLAG    SET LDFLAG TO OTHER THAN 0
01068A	FEC6	86	11	A		LDAA	*%00010001
01069A	FEC8	B7	800A	A		STAA	ACIA0
01070A	FECB	BD	F846	A		JSR	CLRD
01071A	FECE	7D	8131	A		TST	S3FLAG
01072A	FED1	26	22	FEF5		BNE	S300LD    GO TO 300 BAUD ROUTINE
01073		FED3	A	LOAD		EQU	*
01074A	FED3	8D	73	FF48	L1	BSR	INCHR
01075A	FED5	C1	96	A		CMPB	*\$96      LOOK FOR SYNC
01076A	FED7	26	FA	FED3		BNE	L1
01077A	FED9	4F			L2	CLRA	CLEAR CHECKSUM
01078A	FEDA	8D	6C	FF48		BSR	INCHR    GET BYTE COUNT
01079A	FEDC	27	10	FEFF		BEQ	QUIT    QUIT IF ZERO
01080A	FEDE	8D	2B	FF0B		BSR	PIN
01081A	FEE0	8D	66	FF48		BSR	INCHR    GET CHECKSUM
01082A	FEE2	4C				INCA	TEST FOR CORRECTNESS
01083A	FEE3	26	0E	FEFB		BNE	ERR    OOPS!
01084A	FEE5	8D	61	FF48		BSR	INCHR    NEXT BLOCK OF DATA
01085A	FEE7	C1	96	A		CMPB	*\$96    ANOTHER SYNC?
01086A	FEE9	27	EE	FED9		BEQ	L2    YES, GO GET IT
01087A	FEEB	7C	8133	A	ERR	INC	ERROR
01088A	FEFF	20	83	FE73	QUIT	BRA	DISP11
01089A	FEF0	CE	396D	A	MESAGE	LDX	*\$396D
01090A	FEF3	20	BC	FEB1		BRA	KEYM

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01092      *
01093      * 300 BAUD LOAD ROUTINE FOR TAPE
01094      *
01095A FEF5 8D 51 FF48 S300LD BSR    INCHR
01096A FEF7 C1 42 A      CMPB   #'B     START OF BINARY?
01097A FEF9 27 09 FF04 BEQ    RDBLCK  YES
01098A FEFB C1 47 A      CMPB   #'G     END OF FILE?
01099A FEFD 26 F6 FEF5 BNE    S300LD
01100A FEFF 7F 8131 A     CLR    S3FLAG
01101A FF02 20 EA FEEE BRA    QUIT
01102A FF04 8D 42 FF48 RDBLCK BSR    INCHR  GET BYTE COUNT
01103A FF06 5C           INCB   PIN    SAVE IT
01104A FF07 8D 02 FF0B BSR
01105A FF09 20 EA FEF5 BRA    S300LD

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01107      *
01108      * INPUT ROUTINE FOR LD AND S300LD
01109      *
01110A FF0B CE 8139 A FIN    LDX    #LDTBLE
01111A FF0E E7 00 A      STAB   0,X
01112A FF10 8D 36 FF48 BSR    INCHR  GET MSB ADDR.
01113A FF12 E7 01 A      STAB   1,X
01114A FF14 8D 32 FF48 BSR    INCHR  GET LSB ADDR.
01115A FF16 E7 02 A      STAB   2,X
01116A FF18 EE 01 A      LDX    1,X  RETRIEVE START ADDR.
01117A FF1A 7D 8137 A     TST    INIT2
01118A FF1D 26 06 FF25 BNE    NEXT1
01119A FF1F 7C 8137 A     INC    INIT2
01120A FF22 FF 8129 A     STX    UPC   SAVE INITIAL STARTING ADDR.
01121A FF25 8D 21 FF48 NEXT1 BSR    INCHR  GET DATA
01122A FF27 7D 8132 A     TST    VERIFY VERIFY MODE?
01123A FF2A 27 08 FF34 BEQ    STORE  NO, SO STORE CHAR IN MEMORY
01124A FF2C E1 00 A      CMPB   0,X  TEST AGAINST WHATS IN MEMORY
01125A FF2E 27 06 FF36 BEQ    NEXT2 ITS THE SAME-CHECK NEXT ONE
01126A FF30 32          PULA
01127A FF31 32          PULA
01128A FF32 20 B7 FEEB BRA    ERR   PRINT ERROR MESSAGE
01129A FF34 E7 00 A      STORE  STAB   0,X  PUT IT IN MEMORY
01130A FF36 08          NEXT2 INX
01131A FF37 7A 8139 A     DEC    LDTBLE DEC BYTE COUNT
01132A FF3A 26 E9 FF25 BNE    NEXT1 AGAIN?
01133A FF3C 39          RTS   **RETURN**

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01135          *
01136          * PUNCH LEADER
01137          *
01138A FF3D CE 0019 A PNLDRI LDX    *$0019
01139A FF40 C6 FF   A PNLDRI LDAB   *$FF      OUTPUT ALL ONES
01140A FF42 8D 28 FFEC           BSR      WRITE
01141A FF44 09                 DEX
01142A FF45 26 F9 FF40           BNE     PNLDRI
01143A FF47 39                 RTS      ***RETURN***
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01145          *
01146          * SUBROUTINE TO PUNCH AND LOAD A BYTE
01147          *
01148A FF48 36     INCHR  PSHA      INPUT A CHARACTER
01149A FF49 B6 800A A INCHR2 LDAA   ACIA0      LOOK FOR A NEW CHARACTER
01150A FF4C 47     ASRA
01151A FF4D 24 FA FF49           BCC     INCHR2      TEST FOR ONE
01152A FF4F 32     RQ      PULA
01153A FF50 BD FFE4 A           JSR      IRQ
01154A FF53 39                 RTS      ***RETURN***
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01156          *
01157          * OUTPUT ROUTINE FOR S1200P AND S300P
01158          *
01159A FF54 E6 01   A POUT    LDAB   1,X      OUTPUT MSB ADDR.
01160A FF56 8D 14 FF6C           BSR      WRITE
01161A FF58 E6 02   A           LDAB   2,X      OUTPUT LSB ADDR.
01162A FF5A 8D 10 FF6C           BSR      WRITE
01163A FF5C EE 01   A           LDX    1,X      SET INDEX TO DATA
01164A FF5E E6 00   A P2      LDAB   0,X      OUTPUT DATA BYTE
01165A FF60 8D 0A FF6C           BSR      WRITE
01166A FF62 08                 INX
01167A FF63 7A 8139 A           DEC     BCOUNT
01168A FF66 26 F6 FF5E           BNE     P2
01169A FF68 FF 813A A           STX     BEGA      UPDATE BEGINNING ADDR
01170A FF6B 39                 RTS
01171A FF6C 36     WRITE   PSHA
01172A FF6D 7F 8138 A           CLR     LDFLAG
01173A FF70 B6 800A A WRITE2  LDAA   ACIA0
01174A FF73 47                 ASRA
01175A FF74 47                 ASRA
01176A FF75 24 F9 FF70           BCC     WRITE2
01177A FF77 20 D6 FF4F           BRA     RQ
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01179          *
01180          * 300 BAUD PUNCH ROUTINE
01181          *
01182A FF79 CE 0200 A S300P LDX    *$200
01183A FF7C 8D C2 FF40 BSR    PNLDRL  PUNCH LEADER
01184A FF7E 8D 58 FFD8 PUND10 BSR    ADDR   DETERMINE MAX BLOCK LENGTH
01185A FF80 27 02 FF84 BEQ    PUND25  DIFF LESS THAN 255
01186A FF82 C6 FF   A LDAB   *$FF  YES, SET BLOCK = 255
01187A FF84 E7 00  A PUND25 STAB   0,X   SAVE BYTE COUNT
01188A FF86 C6 42  A LDAB   #'B   PUNCH B
01189A FF88 8D E2 FF6C BSR    WRITE
01190A FF8A E6 00  A LDAB   0,X   PUNCH BYTE COUNT
01191A FF8C 8D DE FF6C BSR    WRITE
01192A FF8E 6C 00  A INC    0,X   ADJUST BYTE COUNT
01193A FF90 8D C2 FF54 BSR    POUT
01194A FF92 8D A9 FF3D BSR    PNLDRL1 PUNCH 25 ONES
01195A FF94 FE 813A A  LDX    BEGA   RESTORE XR
01196A FF97 09          DEX
01197A FF98 BC 813C A  CPX    ENDA
01198A FF9B 26 E1 FF7E BNE    PUND10 NO
01199A FF9D C6 47  A LDAB   #'G
01200A FF9F 8D CB FF6C BSR    WRITE
01201A FFA1 7F 8137 A QUIT1 CLR    INIT2
01202A FFA4 8D 97 FF3D BSR    PNLDRL1
01203A FFA6 39          RTS    ***RETURN***
```

```

01205          *
01206          * PUNCH EITHER 300 OR 1200 BAUD
01207          *
01208A FFA7 86 51  A PUNCH  LDAA   *X01010001
01209A FFA9 B7 800A A STAA   ACIA0
01210A FFAE 7D 8131 A TST    SBFLAG
01211A FFAF 26 C8 FF79 BNE    S300P  GO PUNCH A 300 BAUD TAPE
```

01213 \*  
 01214 \* PUNCH 1200 BAUD BINARY  
 01215 \*  
 01216A FFB1 CE 0900 A S1200P LDX #\$900  
 01217A FFB4 8D 8A FF40 BSR PNLD  
 01218A FFB6 FE 813C A LDX ENDA RETREIVE END ADDR.  
 01219A FFB9 08 INX MAKE IT ONE MORE  
 01220A FFBA FF 813C A STX ENDA  
 01221A FFBD 8D 19 FFD8 LOOP00 BSR ADDR CALCULATE BLOCK LENGTH  
 01222A FFBF 27 02 FFC3 BEQ P1  
 01223A FFC1 C6 FF A LDAB #\$FF DEFAULT BYTE COUNT  
 01224A FFC3 E7 00 A P1 STAB 0,X BYTE COUNT SAVED  
 01225A FFC5 C6 96 A LDAB #\$96 OUTPUT SYNC  
 01226A FFC7 8D A3 FF6C BSR WRITE  
 01227A FFC9 4F CLRA CLEAR CHECKSUM  
 01228A FFCA E6 00 A LDAB 0,X OUTPUT BLOCKLENGTH  
 01229A FFCC 8D 9E FF6C BSR WRITE  
 01230A FFCE 27 D1 FFA1 BEQ QUIT1 GET OUT IF ZERO LENGTH  
 01231A FFD0 8D 82 FFS4 BSR POUT  
 01232A FFD2 43 COMA OUTPUT CHECKSUM  
 01233A FFD3 16 TAB  
 01234A FFD4 8D 96 FF6C BSR WRITE  
 01235A FFD6 20 E5 FFBD BRA LOOP00 DO NEXT BLOCK

01237 \*  
 01238 \* ADDR IS USED TO CALCULATE BLOCK SIZE IN LOAD  
 01239 \*  
 01240A FFD8 CE 8139 A ADDR LDX \*LDTBLE  
 01241A FFDB E6 04 A LDAB 4,X LSB END ADDR.  
 01242A FFDD E0 02 A SUBB 2,X LSB START ADDR.  
 01243A FFDF A6 03 A LDAA 3,X MSB END ADDR.  
 01244A FFE1 A2 01 A SBCA 1,X MSB START ADDR.  
 01245A FFE3 39 RTS  
 01246A FFE4 7D 8138 A IRQ TST LDFLAG DO THE ACTUAL OUTPUT/INPUT  
 01247A FFE7 26 05 FFEE BNE INPUT1  
 01248A FFE9 F7 800B A STAB ACIA1  
 01249A FFEC 20 03 FFFF BRA IRQEND  
 01250A FFEE F6 800B A INPUT1 LDAB ACIA1  
 01251A FFF1 1B IRQEND ABA CALCULATE CHECKSUM  
 01252A FFF2 39 RTS \*\*\*RETURN\*\*\*

01254A FFF8		ORG	\$FFFF
01255A FFF8	F95F	A IRQV	FDB UIRQ IRQ VECTOR
01256A FFFA	F8B3	A SWIV	FDB SWINT SWI VECTOR
01257A FFFC	F87F	A NMIV	FDB NONMSK NMI VECTOR
01258A FFFE	F800	A RSTV	FDB RESTRT RESTART VECTOR

* D3BUG OPERATING STACK					
01260					*
01261					*
01262A 8100		ORG	\$8100		
01263A 8100	0002	A MNPTR	RMB	2	ADDRESS OF 'MAIN' LOOP
01264A 8102	0002	A UHASH	RMB	2	USER SPECIAL FUNCTION POINTER
01265A 8104	0002	A UNMIV	RMB	2	USER NMI VECTOR
01266A 8106	0002	A UIRQV	RMB	2	USER IRQ VECTOR
01267A 8108	0002	A USWIV	RMB	2	USER SWI VECTOR
01268		* GTEMP & GXTMP ARE USED IN AN INTERRUPT DRIVEN			
01269		* ROUTINE -- USE EXTREME CARE IF USED ELSEWHERE			
01270A 810A	0001	A GTEMP	RMB	1	TEMP STORAGE LOCATION
01271A 810B	0002	A GXTMP	RMB	2	DOUBLE BYTE TEMP STORAGE
01272A 810D	0002	A XTMP1	RMB	2	.
01273A 810F	0002	A XTMP2	RMB	2	.
01274A 8111	0002	A XTMP3	RMB	2	.
01275A 8113	0002	A XCALC	RMB	2	TEMP CALCULATION BUFFER
01276A 8115	0001	A DIGEN	RMB	1	ROTATING DIGIT ENABLE BIT
01277A 8116	0001	A REGNUM	RMB	1	REGISTER NUMBER FOR REGDIS
01278A 8117	0001	A KEY	RMB	1	DECODED KEY VALUE
01279A 8118	0004	A HEXBUF	RMB	4	4-BYTE HEX BUFFER
01280A 811C	0008	A DISBUF	RMB	8	8-BYTE DISPLAY BUFFER (7-SEG)
01281	8124	A SAVSTK	EQU	*	
01282A 8124	0001	A UCC	RMB	1	USER REGISTER CONDITION CODES
01283A 8125	0001	A UB	RMB	1	ACCUMULATOR B
01284A 8126	0001	A UA	RMB	1	ACCUMULATOR A
01285A 8127	0002	A UX	RMB	2	INDEX REGISTER
01286A 8129	0002	A UFC	RMB	2	PROGRAM COUNTER
01287A 812B	0002	A USP	RMB	2	USER STACK POINTER
01288A 812D	0001	A INIT1	RMB	1	FRESH START FLAG
01289A 812E	0001	A ROWCOL	RMB	1	CODED KEY CLOSURE FROM GET
01290A 812F	0001	A NFLAG	RMB	1	TRACE FLAG
01291A 8130	0001	A EXFLAG	RMB	1	EXPANSION ROM PRESENCE FLAG
01292A 8131	0001	A S3FLAG	RMB	1	USED IN PLOAD FOR SPEED OF I/O
01293	8132	A VERIFY	EQU	*	FLAG USED IN PLOAD FOR TAPE VERIFY
01294A 8132	0001	A INIT	RMB	1	GEN PURPOSE FIRST PASS FLAG
01295A 8133	0001	A ERROR	RMB	1	USED IN PLOAD FOR CHECKSUM ERROR
01296A 8134	0001	A ROLFLG	RMB	1	ROLENTR FIRST PASS FLAG
01297A 8135	0001	A FLG24	RMB	1	ROLENTR 2/4 NIBBLE MODE FLAG(CLR=4)
01298A 8136	0001	A FNCFLG	RMB	1	FUNCTION FLAG(FUNC SET/CLEAR)
01299A 8137	0001	A INIT2	RMB	1	FRESH 2ND START FLAG
01300A 8138	0001	A LDFLAG	RMB	1	USED IN PLOAD FOR I/O DIRECTION
01301	8139	A LDTBLE	EQU	*	TABLE USED BY PLOAD FOR ADDR
01302A 8139	0001	A BCOUNT	RMB	1	HOLDS BYTE COUNT FOR PLOAD
01303A 813A	0002	A BEGA	RMB	2	HOLDS BEGINNING ADDR FOR PLOAD
01304A 813C	0002	A ENDA	RMB	2	HOLDS ENDING ADDR FOR PLOAD
01305A 813E	0002	A POINTR	RMB	2	USED IN BKPT ROUTINE
01306A 8140	0002	A TOFT	RMB	2	USED IN BKPT
01307A 8142	0001	A NUMBER	RMB	1	.
01308	8143	A BOF	EQU	*	
01309A 8143	0010	A	RMB	16	BREAKPOINT TABLE
01310	8153	A EOF	EQU	*	
01311A 8153	0010	A	RMB	16	AUX BREAKPOINT TABLE
01312			END		
TOTAL ERRORS 00000					

800A ACIA0 00106\*00993 01069 01149 01173 01209  
800B ACIA1 00107\*01248 01250  
FCF6 ACTION 00847 00856\*  
FD09 ACTON2 00857 00863\*  
FFD8 ADDR 01184 01221 01240\*  
F94D ADDXA 00324\*00381 00639 00732  
FA6A ADV1 00483 00489\*  
FA7D ADV2 00490 00497\*  
FA96 ADV3 00498 00507\*  
FAA6 ADV4 00508 00514\*  
FA86 ADV5 00515 00521\*  
FC61 ALDUN 00770 00778\*  
FAD9 ARN1 00537 00539\*  
FCCA ARN17 00829 00832\*  
F9F6 ARN1M 00435 00438\*  
F95B ARND 00327 00329\*  
F8F7 ARND1 00272 00274\*  
FBEF BADOFS 00687 00690 00694 00698\*  
FCA5 BADSTK 00808 00818\*  
8139 BCOUNT 01167 01302\*  
813A BEGA 01003 01169 01195 01303\*  
FAF4 BEGIN 00553 00557\*  
F8E7 BKP 00267\*  
F901 BKPCNT 00279\*  
FA3C BLANK 00464 00467\*  
8143 BOF 00130 00851 00859 00871 00879 00908 00909 00916 00956 00958 00971  
FB63 BOT2 00610 00621\*  
FB75 BOT4 00612 00629\*  
F9A2 CLOP 00373\*00374  
FA47 CLR1 00471 00473\*  
FA45 CLR14 00469 00472\*  
F846 CLRD 00167\*00182 00813 01054 01070  
F848 CLRDSP 00168\*00473 00648 00673 00776 00914 01027  
F97F COLFND 00349 00354\*  
F971 COLUMN 00347\*00352  
FCDA CONT 00843 00846\*  
F8CC CONTIN 00212 00252 00255\*  
8115 DIGEN 00295 00296 00309 01276\*  
811C DISBUF 00168 00173 00185 00298 00461 00466 00675 00727 00767 00820 00822  
8089 DISCTR 00101\*00211 00230  
F8A4 DISNMI 00140 00213 00227\*  
FB1A DISP 00562 00569 00575\*  
FBB9 DISP1 00601 00673\*  
FE75 DISP10 01024 01026\*  
FE73 DISP11 01008 01025\*01088  
FE66 DISP2 01004 01020\*  
FD73 DISPLAY 00855 00908\*00955  
FD7F DISPLAY 00867 00885 00907 00912\*  
FD7C DISPLAY1 00862 00911\*00957  
8088 DISREG 00100\*00138 00210 00303 00305 00345  
F949 DLY 00316 00318\*00319  
F946 DLY1 00304 00317\*  
F941 DLY25 00315\*00384  
FB93 DONE 00647\*  
FBB5 DSP 00671\*  
FB67 DUBROL 00614 00623\*  
FA91 DUNADV 00505\*00525  
FA16 DUNPAS 00448 00452\*00506

FC08 DYS 00577 00707\*  
FC0B DYSCOD 00457 00646 00671 00707 00713\*00912 01026  
FC3C DYSTBL 00730 00745\*  
F839 EFPI 00146 00153\*00306 00789  
FE1B END 00961 00973 00986\*  
813C ENDA 01018 01197 01218 01220 01304\*  
FD87 ENDBPT 00891 00894 00915\*00935 00937  
FEA0 ENDFST 01046 01049\*  
FC0A ENDOFF 00678 00708\*  
F8AF ENNMI 00199 00221 00236\*  
8153 EOF 01310\*  
FEEB ERR 01083 01087\*01128  
8133 ERROR 01055 01066 01087 01295\*  
8130 EXFLAG 00147 00218 00293 00342 00582 00791 01291\*  
F008 EXGET 00111\*00112 00344 00584  
F00E EXKEY 00113\*00292  
F00B EXPUT 00112\*00113  
F005 EXREEN 00110\*00111  
F000 EXROM 00108\*00109 00160  
F002 EXSTRT 00109\*00110 00148  
F&3F EXTST 00144 00160\*00290  
FC59 FCLR 00661 00775\*  
FDAD FCLR33 00888 00934\*  
8135 FLG24 00504 00524 00555 00599 00605 00613 00705 00865 01000 01297\*  
FBC2 FNC 00669 00677\*  
FB79 FNCDCD 00197 00635\*  
8136 FNCFLG 00643 00769 00777 00796 00842 00995 01298\*  
FD88 FNDBRK 00251 00893 00916\*00936  
FB9E FNHASH 00637 00656\*  
FDAC FOUND 00925 00932\*  
FC4C FSET 00660 00766\*  
FD41 FSET33 00870 00887\*  
FE7F FSTCLR 01009 01030\*01065  
FC76 FTST 00793 00796\*  
FD16 FUNCTN 00864 00868\*  
FB0F FUNDIS 00556 00565 00571\*  
FB01 FUNKEY 00558 00563\*  
F964 GET 00220 00342\*00353 00364  
F96C GET1 00343 00345\*  
FAC4 GETIT 00530\*00586  
FC64 GO 00280 00659 00789\*  
FE4B G000 01006 01009\*  
FEC0 G01 01034 01066\*  
FCB6 GOEXIT 00817 00824\*  
FB0A GOKEY 00568\*  
FBE6 GOOD 00692 00694\*  
FBE5 GOODOF 00688 00693\*  
FC8A GOTO 00803\*00845  
810A GTEMP 00355 00358 01270\*  
810B GXTMP 01271\*  
FB80 HASCLC 00638\*00651  
FB8A HEX 00636 00643\*  
8118 HEXBUF 00247 00250 00454 00456 00477 00478 00487 00493 00495 00501 00503  
00573 00576 00611 00615 00621 00624 00625 00628 00629 00683 00685  
00794 00854 00861 00882 00884 00896 00898 00906 00911 00920 00921  
FDE1 INBKFT 00802 00958\*  
FF48 INCHR 01074 01078 01081 01084 01095 01102 01112 01114 01121 01148\*  
FF49 INCHR2 01149\*01151

FDA1 INCX 00923 00926\*  
8132 INIT 00263 00428 00430 00552 00554 01294\*  
812D INIT1 00129 00846 00849 01288\*  
8137 INIT2 00191 00548 00595 00597 00706 00856 00858 00997 01001 01014 01017  
FE41 INPUT 00998 01005\*  
FFEE INPUT1 01247 01250\*  
FFE4 IRQ 01153 01246\*  
FFF1 IRQEND 01249 01251\*  
FFF8 IRQV 01255\*  
8117 KEY 00383 00533 01278\*  
F9A6 KEYCOD 00375\*  
FEB1 KEYM 01060\*01090  
F899 KEYNMI 00215 00218\*  
F9BF KEYTBL 00380 00392\*  
FB22 KEYTST 00438 00557 00582\*00635 00668 00863 01005 01063  
FED3 L1 01074\*01076  
FED9 L2 01077\*01086  
FEA1 LD 00996 01054\*  
8138 LDFLAG 01067 01172 01246 01300\*  
8139 LDTBLE 01110 01131 01240 01301\*  
FED3 LOAD 01073\*  
FDE6 LOOP 00960\*00970  
FFBD LOOP00 01221\*01235  
F869 LOOP1 00189\*00192  
F8CF LOOP10 00256\*00260  
FD99 LOOP1M 00922\*00930  
FDB8 LOOP20 00939\*00947  
FE00 LOOP40 00972\*00985  
FB69 LOOPM 00624\*00627  
F84B LOP 00169\*00174  
FC0F LF01 00715\*00726  
FC25 LP02 00729\*00738  
F91B LP1 00296\*00310  
F924 LP2 00299\*00301  
F905 MAIN 00278 00281\*  
FADC MEMCH 00548\*00656  
FEF0 MESAGE 01056 01089\*  
8100 MNPTR 00198 00282 00307 00641 00799 01263\*  
FF25 NEXT1 01118 01121\*01132  
FF36 NEXT2 01125 01130\*  
812F NFLAG 00188 00264 00281 00445 00828 00844 01290\*  
FFFC NMIV 01257\*  
F8A6 NMIX 00228\*00237  
F87F NONMSK 00207\*01257  
FC87 NORMGO 00797 00802\*  
FDAA NOTFND 00919 00927 00931\*  
8142 NUMBER 00850 00860 00883 00889 00904 00905 00918 00952 00953 01307\*  
FA13 NUMKEY 00439 00451\*  
FE91 NXT 0103E 01041\*  
FE88 NXT0 01030 01035\*  
FE9A NXT1 01042 01045\*  
FB06 OFF 00563 00566\*  
FB32 OFFSET 00549 00567 00595\*  
F8AE OFST 00596 00668\*  
FDC9 OUT 00940 00948\*  
FA8E OUT1 00504\*  
FABF OUT2 00488 00496 00524\*  
FFC3 P1 01222 01224\*

FF5E P2 01164\*01168  
FBF4 PAST 00697 00700\*  
FA23 PAST1 00453 00457\*  
FA32 PAST2 00459 00463\*  
FE7B PEND 01028\*  
FF0B PIN 01080 01104 01110\*  
FE1C PLOAD 00662 00991\*  
FE2C PNCH 00997\*  
FF40 PNLDLR 01139\*01142 01183 01217  
FF3D PNLDLR1 01138\*01194 01202  
813E POINTR 00852 00868 00880 00900 00917 00962 00966 00974 00982 01305\*  
FF54 POUT 01159\*01193 01231  
F871 PROMP1 00196\*00778  
F861 PROMPG 00186\*00823  
F857 PROMPT 00145 00182\*00219 00437 00538 00657  
FFA7 PUNCH 01029 01208\*  
FE7C PUNCH1 01015 01029\*  
FF7E PUND10 01184\*01198  
FF84 PUND25 01185 01187\*  
F90B PUT 00200 00290\*00311 00800  
F913 PUT2 00291 00293\*  
FEEE QUIT 01064 01079 01088\*01101  
FFA1 QUIT1 01201\*01230  
FF04 RDBLCK 01097 01102\*  
FA62 REGAD1 00432 00486\*  
FA4B REGADV 00436 00441 00449 00477\*  
F9DD REGDIS 00276 00428\*00658  
F9EA REGLOP 00429 00433\*  
8116 REGNUM 00431 00452 00458 00479 00481 00484 01277\*  
F800 RESTRT 00123\*01258  
FADB RET 00535 00540\*  
FE9E RET44 01038 01044 01047\*  
FD7D RMBKPT 00267 00971\*  
FB44 ROLEN 00451 00559 00606\*00645 00670 00866 01007  
8134 ROLFLG 00505 00574 00598 00606 00608 00704 00792 00848 00892 00938 01021  
FB56 ROLL 00607 00613\*  
F987 ROW 00358\*00367  
812E ROWCOL 00187 00372 00433 00530 00532 00585 01289\*  
F99A ROWFND 00361 00368\*  
FF4F RQ 01152\*01177  
FFFE RSTV 01258\*  
FFB1 S1200P 01216\*  
FEF5 S300LD 01072 01095\*01099 01105  
FF79 S300P 01182\*01211  
8131 S3FLAG 00999 01037 01043 01071 01100 01210 01292\*  
8124 SAVSTK 01281\*  
808B SCNCTR 00103\*00214 00228  
808A SCNREG 00102\*00136 00154 00183 00297 00385  
FD31 SKIP 00874 00878 00880\*  
FB2A SKIP1 00583 00585\*  
F850 SKIP11 00170 00172\*  
FD27 SKIP2 00872 00875\*  
FA8B SOUT1 00503\*00513 00520  
817F STKTOP 00099\*00123 00196 00262  
FF34 STORE 01123 01129\*  
F8B3 SWINT 00244\*01256  
FFFA SWIV 01256\*  
FC00 TBRK 00663 00842\*

8085 TCNTRL 00104\*00208 00831  
8086 TMRMSB 00105\*00128  
8140 TOFT 00131 00853 00873 00877 00895 00903 00926 00939 00948 00951 00960  
FA0A TRAC 00443 00447\*  
FA0E TRAC1 00446 00449\*  
FCD5 TRACE 00450 00844\*  
F8FB TRCE 00266 00276\*  
8126 UA 00500 00503 00826 01284\*  
8125 UB 00510 00516 00825 01283\*  
8124 UCC 00255 00258 00517 00521 00832 01282\*  
8102 UHASH 00650 01264\*  
F95F UIRO 00334\*01255  
8106 UIRQV 00334 01266\*  
8104 UNMIV 00216 01265\*  
8129 UPC 00268 00274 00486 00491 00795 00798 00801 00809 00811 01120 01286  
FB99 USERFN 00644 00650\*  
812B USP 00126 00261 00485 00522 00803 01287\*  
8108 USWIV 00253 00273 01267\*  
8127 UX 00492 00499 00824 01285\*  
8132 VERIFY 00991 01031 01122 01293\*  
FE14 WHOOPS 00979 00982\*  
FF6C WRITE 01140 01160 01162 01165 01171\*01189 01191 01200 01226 01229 01234  
FF70 WRITE2 01173\*01176  
8113 XCALC 00324 00325 00326 00328 00329 01275\*  
810D XTMP1 01272\*  
810F XTMP2 00729 00734 01273\*  
8111 XTMP3 00551 00679 00681 00684 00686 00701 00994 01020 01274\*



## **APPENDIX 2**

### **PARTS LIST**



APPENDIX 2. PARTS LIST

Item Number	Quantity	Description	Part Number	Reference Designation
1	1	PC Board	MEK6802D3	-
2	1	Integrated Circuit	74LS01N	U7
3	1	Integrated Circuit	74LS10N	U12
4	1	Integrated Circuit	74LS20N	U27
5	1	Integrated Circuit	74LS28N	U1
6	1	Integrated Circuit	74LS27N	U13
7	2	Integrated Circuit	74LS138N	U10, U11
8	2	Integrated Circuit	74LS241N	U2, U3
9	4	Integrated Circuit	74LS244N	U4, U5, U6, U17
10	1	Integrated Circuit	MC6802P	U26
11	2	Integrated Circuit	MC6810P	U30, U31
12	1	Integrated Circuit	MC6821P	U8
13	1	Integrated Circuit	MC6846P	U9
14	1	Integrated Circuit	MC14539BCP	U28
15	5	Integrated Circuit	MC75452P	U14, U15, U16, U33, U34
16	1	Crystal, 3.579545 MHz	NDK, CTS, Buck-Man	Y1
17	1	Socket, IC , 16-Pin		(For SK1)
18	3	Socket, IC , 24-Pin		U29, U30, U31
19	8	Socket, 14-Pin		U18-U25
20	3	Socket, 20 Count		P1
21	3	Socket, IC, 40-Pin		U8, U9, U26
22	1	Resistor Array, 8-10K Ohm	Bourns, Beckman	U32

## APPENDIX 2. PARTS LIST (cont'd)

Item Number	Quantity	Description	Part Number	Designation
23	1	Resistor, SIP, 3.3K Ohm	Bourns, Beckman	Z2
24	3	Resistor, 3.3K Ohm 1/4 watt, 5%		R1, R6, R7
25	4	Resistor, 10K Ohm 1/4 watt, 5%		R2, R3, R4, R5
26	1	Capacitor, 100 Micro Farad Electrolytic		C7
27	2	Capacitor, 27 Pico Farad DM - Dipped Silver Mica		C19, C20
28	24	Capacitor, 0.1 Micro Farad Monolithic Ceramic		C1-C6, C8-C16, C18, C21-C28
29	1	Capacitor, 1.0 Micro Farad Monolithic		C17
30	8	LED, 7-segment	Monsanto Man 74	U18, U25
31	1	Hex, Keypad	KB Denver- Custom	
32	4	Jumper, Zero Ohm Resistor		E2, E4, E5, E9
33	1	Key, Polarizing		(For P1)
34	1	Wafer Assembly, 5	Molex, Methode, Berg	(To ship with board)
35	1	Lens, PCB Display		
36	1	Test Point, Black (GND)		TP2
37	1	Test Point, Yellow (VCC)		TP1
38	2	Test Point, White (Signal)		TP3, TP4
39	3	20 pin Female connector	Molex	P1

## **APPENDIX 3**

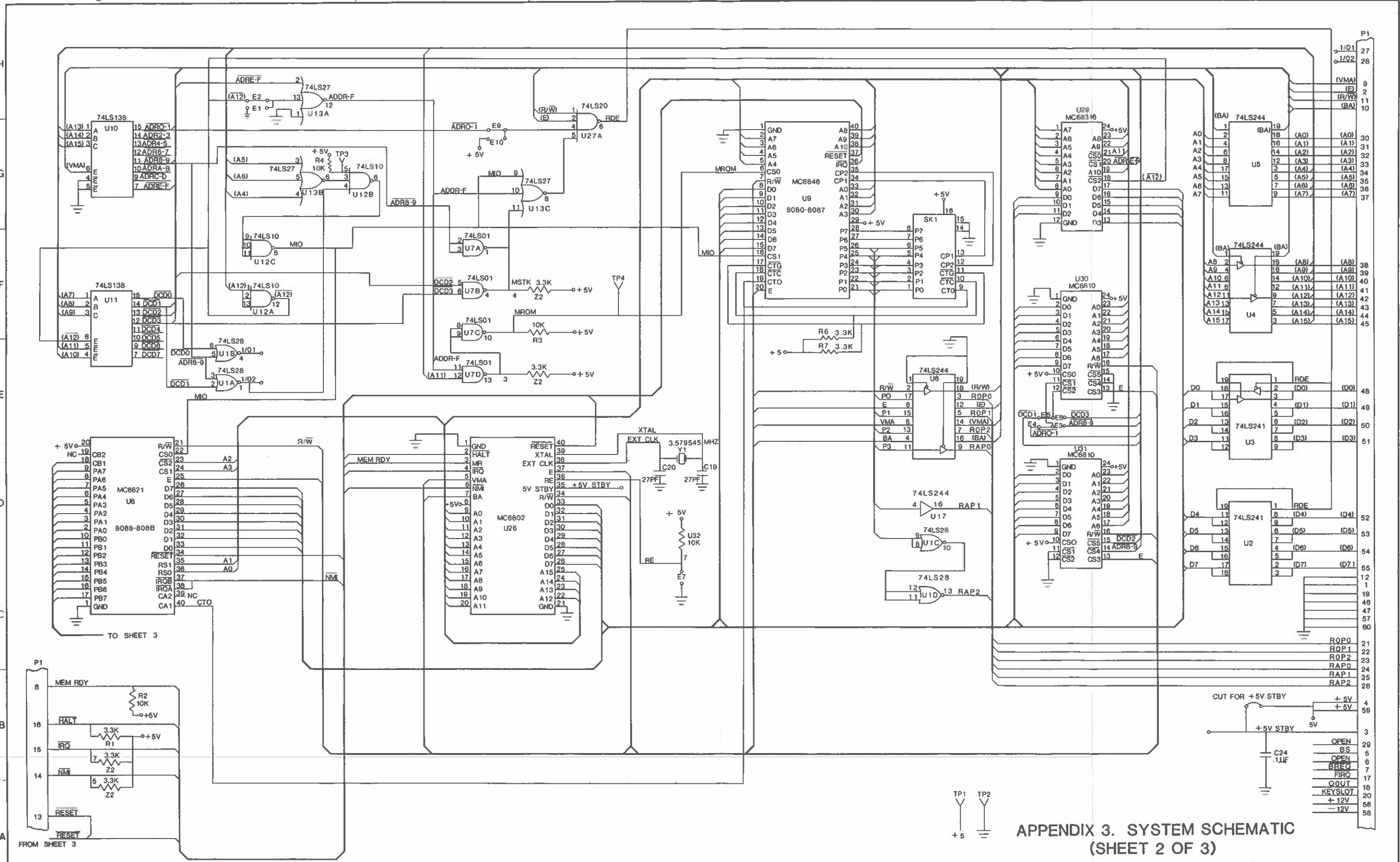
### **SYSTEM SCHEMATIC**

Sheet 1: Index Page

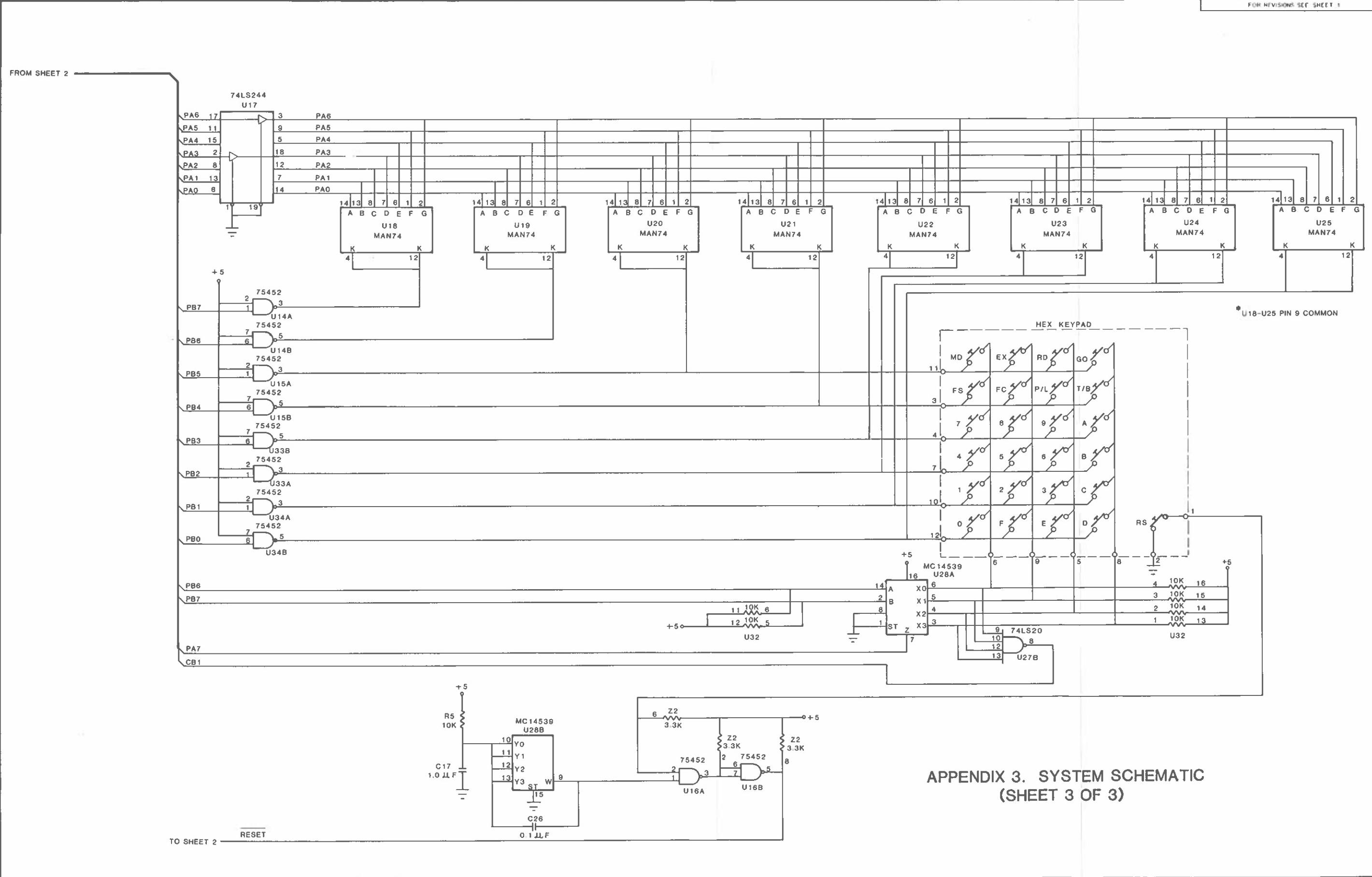
Sheet 2: System Schematic

Sheet 3: System Schematic





**APPENDIX 3. SYSTEM SCHEMATIC  
(SHEET 2 OF 3)**



## **APPENDIX 4**

### **DATA SHEETS**

**MC6802  
MC6846  
MC6821**